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Findings of CO Hot Spot Analysis for Mecklenburg County, North Carolina

Peat, Marwick, Mitchell and Co.
Washington, DC

Prepared for

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Final Report
Prepared For

Analysis of Transportation Control Measures
For Attainment of National Ambient Air Quality
Standards for Mecklenburg County, N.C.

EPA Contract 68-02-3506

March 11, 1982

Peat, Marwick, Mitchell & Co.

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1990 K Street, N.W.
Washington, D.C. 20006

March 11, 1982

Ms. Nancy Williams
Charlotte Department of
Transportation
600 E. Trade Street
Charlotte, North Carolina 28208

Dear Ms. Williams:

Peat, Marwick, Mitchell & Co. is pleased to submit 35 copies of our final report, "Findings of CO Hot Spot Analysis for Mecklenburg County, N.C.," prepared under EPA Contract 68-02-3506. This report reflects comments of the Charlotte Department of Transportation and U.S. Environmental Protection Agency on the draft final report.

It has been a pleasure working with you on this project.

Very truly yours,

PEAT, MARWICK, MITCHELL & CO.

Peat, Marwick, Mitchell & Co.

i.a

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j.b

Peat, Marwick, Mitchell & Co.

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I. INTRODUCTION

BACKGROUND

Mecklenburg County, North Carolina, has been designated by the Environmental Protection Agency as a nonattainment area for carbon monoxide. As a nonattainment area, the 1977 Clean Air Act Amendments require that an alternatives analysis of transportation control measures (TCMs) be performed and a strategy developed to bring the area into compliance with the National Ambient Air Quality Standards by the end of 1987. As a part of this effort, a previous study[1] has screened 29 intersections in the Charlotte area and has identified the following four CO hot spot intersections:

- Sharon Amity Road and Central Avenue;
- Sharon Amity Road and Albemarle Road;
- Sharon Amity Road and Independence Boulevard; and
- Independence Boulevard and Idlewild Road.

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[1] "Review and Update of Modeling Analysis of Carbon Monoxide Emissions in Mecklenburg County, North Carolina." Engineering Science, July 1981.

OBJECTIVE OF THIS STUDY

The objective of this study was to perform an alternatives analysis and develop a strategy for reducing the concentration of CO at the four hot spot intersections identified in the screening analysis. Specifically, this analysis evaluated alternative sets of TCMs for the four CO hot spots, developed alternative control strategies, and estimated the effect that these alternatives have an CO concentrations.

This reports presents:

- a description of the CO hot spots;
- the approach used to develop and analyze TCMs;
- the evaluation of each alternative control measure strategy; and
- the study's recommendations.

II. DESCRIPTION OF HOT SPOTS

SUMMARY OF PRIOR WORK

The 1981 Engineering Science study screened 29 intersections in Mecklenburg County, North Carolina, for sites that may, in 1987 exceed the 8-hour National Ambient Air Quality Standard (NAAQS) for CO of $10mg/m^3$. This analysis used the Intersection Midblock Model together with 1987 MOBILE 2 emission factors. Engineering Science also assumed that:

- an Inspection-Maintenance Program would be implemented in 1982;
- national cold and hot starting percentages apply to Charlotte; and
- traffic volumes in 1987 would be unchanged from 1980 traffic levels.

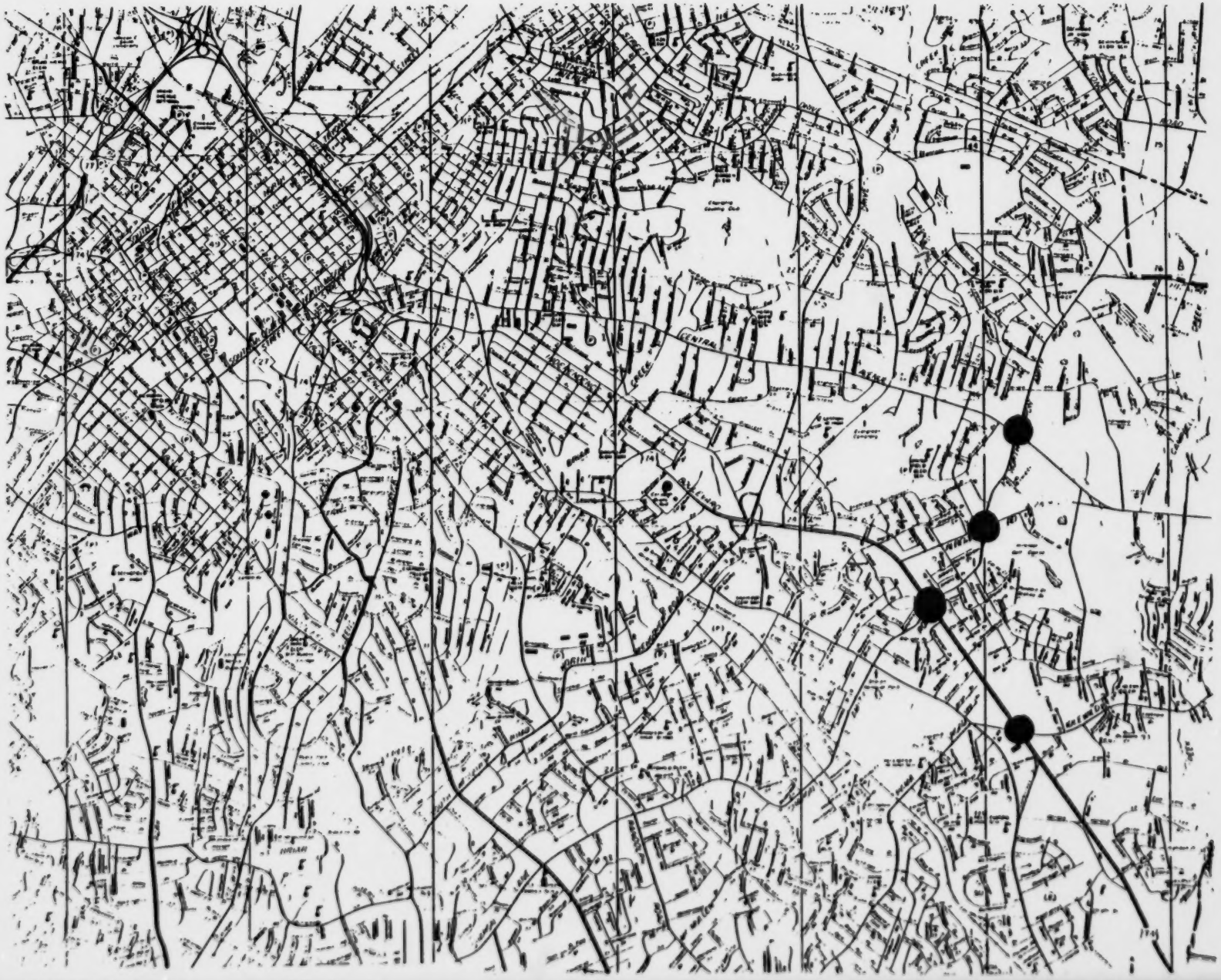
Based on these assumptions, the four CO hot spot intersections mentioned in Section I were identified. These four hot spot intersections are located within 2 miles of one another in the growing eastern suburban areas of Charlotte (Exhibit II-1).

HOT SPOT CHARACTERISTICS

Available traffic counts from the Charlotte Department of Transportation indicate that long queues of idling vehicles form during peak periods at the hot spot intersections.

EXHIBIT II-1

POTENTIAL HOT SPOT LOCATIONS IN CHARLOTTE, NORTH CAROLINA



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This situation, when combined with adverse meteorological conditions can create high concentrations of CO in the vicinity of the intersections which exceed the NAAQS 8-hour CO standard of $10mg/m^3$.

To reduce these CO concentrations to a level less than the NAAQS, strategies must be adopted which reduce vehicle idling and traffic congestion at the hot spot intersetions. This goal will be difficult to achieve since traffic in the eastern suburbs of Charlotte is expected to grow rapidly between 1980 and 1987. This growth will be caused by the rapid residential and commercial growth that is planned in the area.

To reduce traffic congestion at the hot spots despite the great increase in demand will require a carefully tailored control measure strategy. The characteristics of each intersection which influence the choice of control strategies are described in the subsections that follow.

Central Avenue and Sharon Amity Road

The intersection of Central Avenue and Sharon Amity Road is located in the eastern suburbs of Charlotte, adjacent to the Eastland Shopping Mall. Both Central Avenue and Sharon Amity Road are 4-lane arterials, (2 lanes in each direction). Central Avenue is a major radial route into the Charlotte CBD and Sharon Amity is a major circumferential route. Both roads provide access to Eastland Mall within 100 yards of the intersection.

The intersection itself is controlled by a fully actuated signal controller and has separate turn lanes for all left turn movements. The layout of this intersection is shown in Appendix A, Exhibit A-1. Peak hour 1980 traffic volumes for this intersection are shown in Exhibit A-3.

Albemarle Road and Sharon Amity Road

The second hot spot intersection is located 3,000 feet south of the first hot spot along Sharon Amity Road at Albemarle Road. Each approach to this intersection is a 4-lane arterial (2 lanes in each direction). Albemarle Road is a major radial route connecting the eastern suburbs of Charlotte with the Independence Boulevard corridor into the CBD. The land use in the immediate vicinity of the hot spot is strip commercial development.

The intersection itself is controlled by a fully actuated five-phase signal controller and has left turn lanes for all approaches. The physical layout of the intersection is shown in Appendix B, Exhibit B-1, and 1980 peak hour traffic volumes are shown in Exhibit B-3.

Independence Boulevard and Sharon Amity Road

The third hot spot is located approximately 3,500 feet south of the second hot spot along Sharon Amity Road at Independence Boulevard. In the vicinity of this hot spot

Sharon Amity Road is, again, a 4-lane circumferential arterial (2 lanes in each direction) and Independence Boulevard is a 6-lane divided radial arterial (3 lanes in each direction). Independence Boulevard also serves as U.S. Route 74, a major route connecting Charlotte with Wilmington, North Carolina. For this reason, Independence Boulevard handles a much higher percentage of trucks than does other facilities in the area, as shown in Exhibit II-2. The land use in the vicinity of the hot spot is strip commercial development. Both sides of Independence are lined with shopping centers and service stations in the vicinity of the hot spots.

The intersection of Sharon Amity Road and Independence Boulevard is controlled by an 8-phase fully actuated traffic controller with left turn lanes and protected left turn movements for each approach. The layout of this intersection is shown in Appendix C, Exhibit C-1 and the observed 1980 peak hour traffic volumes are shown in Exhibit C-3.

Independence Boulevard and Idlewild Road

The final hot spot intersection is located on Independence Boulevard at Idlewild Road (approximately 5,000 feet southeast of Sharon Amity Road). Independence Boulevard is a 6-lane arterial and Idlewild Road is a 2-lane facility (1 lane in each direction) which feed traffic from the residential areas of eastern Charlotte into the Independence Boulevard and Monroe Road corridors.

EXHIBIT II-2

VEHICLE CLASSIFICATION DISTRIBUTIONS
ASSUMED BY FACILITY

Percent by Vehicle Class

	Auto	LDT1	LDT2	HD	MC
Albemarle Road	87.2%	9.7%	1.8%	1.2%	0.1%
Central Avenue	84.1	13.3	1.9	0.6	0.1
Idlewild Road	90.2	8.4	0.5	0.7	0.2
Independence Blvd.	82.2	12.8	1.8	3.1	0.2
Sharon Amity Road	90.2	8.4	0.5	0.7	0.2

Source: City of Charlotte, Department of Transportation
Traffic Classification Data

Key to Vehicle Classification Abbreviations

Auto: Passenger automobiles

LDT1: Light duty trucks under 6,000 pounds

LDT2: Light duty trucks over 6,000 pounds but under 8,500 pounds

HD: Heavy duty vehicles over 8,500 pounds

MC: Motorcycles

The intersection is controlled by a fully actuated signal controller and has separate left turn lanes for all approaches. The physical layout for this intersection is shown in Appendix D, Exhibit D-1, and the observed 1980 peak hour volumes are shown in Exhibit D-3.

III. ANALYSIS APPROACH

OVERVIEW

Peat Marwick's approach for calculating CO concentrations for each hot spot for alternative sets of transportation control measures was based on EPA's Volume 9 procedure.[1] This procedure was developed and approved by EPA for analyzing CO hot spots and is compatible with the Intersection-Midblock Model used by Engineering Science in its screening of potential hot spots.

INPUTS TO VOLUME 9 PROCEDURE

The following four types of inputs were required for estimating CO concentrations using the Volume 9 procedure:

- traffic volume;
- intersection geometric and signalization characteristics;
- meteorological conditions; and
- receptor locations.

The traffic volume information required for the Volume 9 procedure was developed from 1980 traffic count data obtained from the Charlotte Department of Transportation. These counts were used to estimate 1980 peak hour traffic by movement and

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1 "Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Evaluating Indirect Sources." U.S. Environmental Protection Agency, September 1978.

were factored to represent 1987 conditions. The 1987 traffic forecasts were based on growth factors of 6 percent a year along Albemarle Road and Independence Boulevard (at Sharon Amity Road), 4 percent a year along Idlewild Road and Independence Boulevard (at Idlewild Road), and one percent a year along Sharon Amity Road. No growth was expected for the Central Avenue corridor because that facility was already at or near capacity at a number of points and could not absorb an increase in traffic volumes. These growth rates were prepared by the Charlotte Department of Transportation. The resulting forecasts for 1987 traffic volumes by movement are displayed in Appendices A through D.

The second input, intersection geometrics, included information on the roadway approach width, presence of turning lanes, and signal phasing. This information was obtained from aerial photographs and drawings of each intersection, prepared by the Charlotte Department of Transportation. Information on geometrics and intersection operation for 1987 was based on detailed drawings of proposed intersection operational and safety improvements also developed by the Charlotte Department of Transportation.

The third type of input required by the Volume 9 procedure was meteorological data. The information required was temperature, wind speed and direction, stability, and initial mixing conditions. With one significant exception, the meteorological

data used by Engineering Science in its hot spot screening analysis was also used in this project. The one exception was the use of an air stability class of "E" (slightly stable) instead of "F" (moderately stable) in computing CO concentrations. This revision was made because EPA guidelines in the Volume 9 manual indicated that the appropriate worst case stability class for a suburban site was class "E."[1] This resulted in a more reasonable estimate of the CO concentration (see section on Calibration of Volume 9 Procedure).

The final input to the CO concentration model was receptor location. In each case, the relation of the receptor to the intersection was based on data used by Engineering Science in its screening of potential CO hot spots.

CALIBRATION OF VOLUME 9 PROCEDURE

The accuracy of the Volume 9 procedure used in this project and its comparability with Engineering Science's procedure was determined by using the Volume 9 procedure to calculate 1980 and 1987 CO concentrations at each hot spot using the same assumptions used by Engineering Science. These assumptions included an air

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[1] "Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Evaluating Indirect Sources." U.S. Environmental Protection Agency, September 1975.

stability class of "F," no traffic growth between 1980 and 1987, and no improvements to intersection geometrics. Peat Marwick also modified, slightly, the Volume 9 procedure so that it incorporated MOBILE 2 emission factors instead of the MOBILE 1 factors. The comparison between the Engineering Science and Volume 9 estimates is shown in Exhibit III-1.

As this exhibit indicates, the differences between the Engineering Science and the Volume 9 estimates ranged from 0.6 percent to 11.0 percent. Unfortunately, the Engineering Science procedure appeared to overestimate actual worst case CO concentrations (Exhibit III-2). This over-estimation of CO concentrations is caused in part by the assumption of the air stability class "F." Although class "F" is appropriate for a screening analysis, a more realistic air stability class for this alternatives analysis is class "E." This was the most stringent air stability level recommended by EPA in the Volume 9 procedure for a suburban area. When class "E" was used, the results of the Volume 9 procedure closely matched measured worst case CO concentrations, as demonstrated in Exhibit III-3. The Volume 9 procedure with an atmosphere stability class of "E" was an appropriate technique for analyzing the need for the impact of various CO control strategies. It appeared that this model was sufficiently accurate to use in developing meaningful strategies for reducing CO concentrations to meet the 8-hour NAAQS for CO.

EXHIBIT III-1

VALIDATION OF VOLUME 9 PROCEDURE

CO CONCENTRATIONS (mg/m^3)

	Central and Sharon Amity	Albemarle and Sharon Amity	Independence and Sharon Amity	Idlewild and Independence
1980 Volume 9	29.0			
1980 Eng. Sci.	27.7			
1987 Volume 9*	14.0	9.3	10.9	10.3
1987 Eng Sci.*	13.9	10.4	10.8	11.2

*Includes the effect of Inspection - Maintenance.

EXHIBIT III-2

COMPARISON OF ENGINEERNG SCIENCE
AND OBSERVED WORST CASE
CO CONCENTRATIONS

8-hour CO Concentration (mg/m^3)

Intersection	Measured	Engineering-Science Estimate
Park and Woodlawn	12.7	16.3
Central and Sharon Amity	24.6	27.7

EXHIBIT III-3

COMPARISON OF VOLUME 9 RESULTS AND OBSERVED
WORST 8-HOUR CO CONCENTRATIONS AT
CENTRAL AND SHARON AMITY

	8-hour CO Concentration mg/m3
Volume 9 results	
(Stability class = E, year = 1980)	24.5
(Stability class = F, year = 1980)	29.0
Worst observed 8-hour concentration in 1980	24.6

IV. EVALUATION OF ALTERNATIVE TRANSPORTATION CONTROL MEASURES

SELECTION OF POTENTIALLY APPLICABLE MEASURES

A review of a broad array of TCMs was performed to identify those measures potentially applicable to hot spot intersections in Mecklenburg County. This assessment is presented in Appendix E.

Four transportation control measures were initially identified as being potentially applicable for reducing CO concentrations at Mecklenburg County hot spot intersections. These were:

- traffic flow improvements;
- park-n-ride and fringe parking lots;
- ridesharing; and
- improved public transit.

These strategies were selected from a list of 19 TCMs included in Section 108F of the Clean Air Act. Of the 15 remaining strategies, one (inspection-maintenance) was already scheduled for implementation by 1982 and was accounted for in the CO analysis.

Another six strategies were eliminated because of their limited applicability to CO emissions, requirements for long lead times, and difficulities in enforcement. The six strategies that were eliminated were:

- vapor recovery program;

. long-range transit improvements;

. vehicle idling controls;

. vehicle retrofit;

. reduction of cold start emissions; and

. alternative fuels or engines.

Finally, six strategies were eliminated because these strategies were not applicable to the surburban intersections of arterial streets. These discarded strategies included:

. bus and carpool lanes;

. on-street parking;

. staggered working hours;

. pedestrian malls;

. bicycle lanes; and

. road pricing.

The bus and carpool lanes strategy was dropped from further analysis because high occupancy vehicle (HOV) lanes will generally reduce congestion (and thereby CO concentrations) only if the exclusive lanes are added to existing facilities. When existing lanes are reserved for HOVs the usual result is often increased congestion in the remaining lanes. This congestion results in higher concentrations of CO in the vicinity of the roadway. Unfortunately, given the alignment and development characteristics of the four hot spot intersections in Charlotte, construction of new lanes cannot realistically be expected by 1987. For this reason, the exclusive bus and carpool lanes strategy was dropped from further consideration.

The on-street parking strategy was dropped from this analysis because no on-street parking exists in the immediate vicinity of the hot spot intersections. While the staggered work hours strategy is encouraged throughout the area, it was dropped from consideration because no single large employer existed whose work hours had a significant effect on the traffic parking characteristics at any of the hot spot intersections. Furthermore, the proximity of the hot spots to shopping centers suggested that many afternoon and evening trips through these intersections were not work related and therefore not affected by staggered work hours.

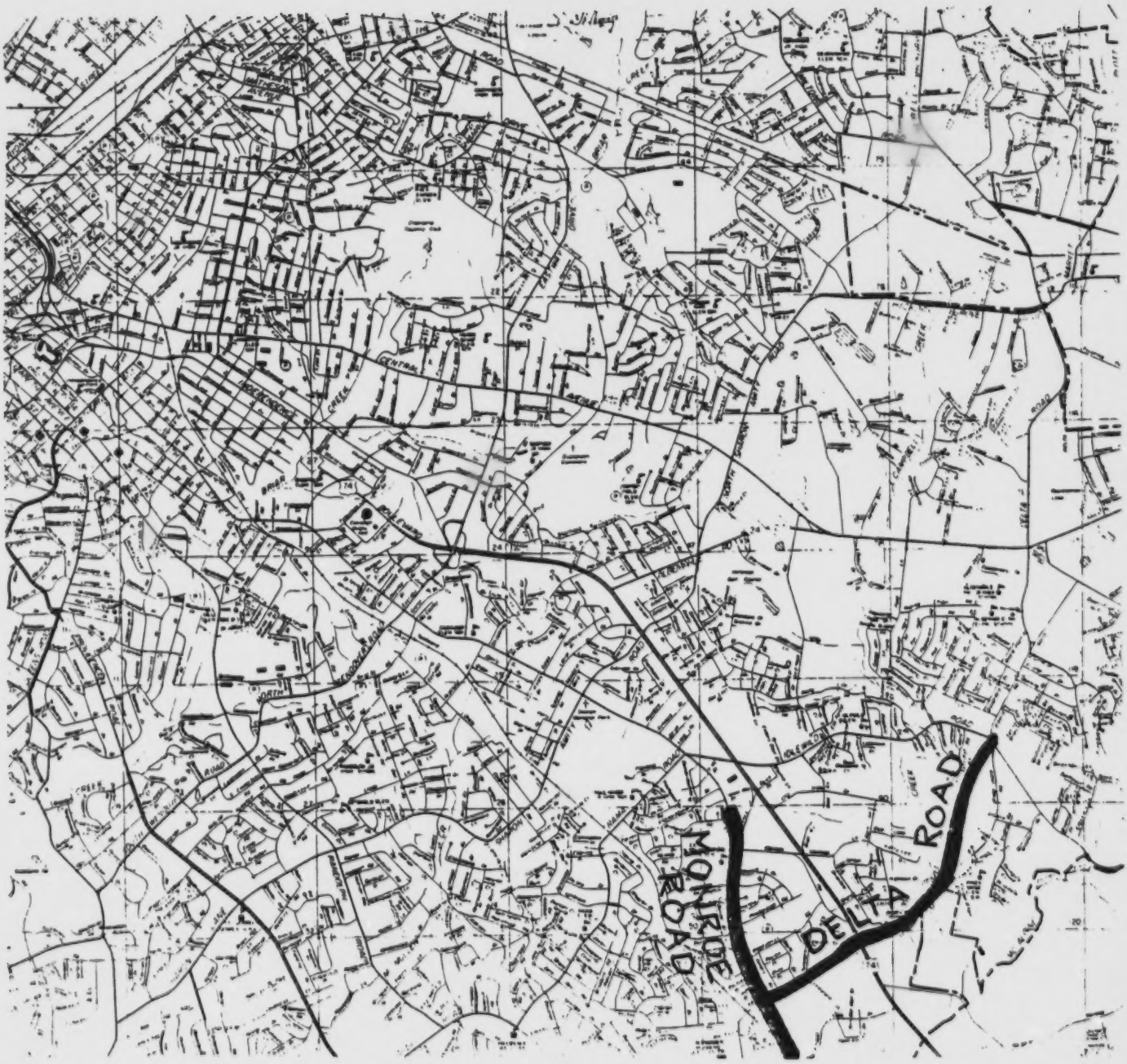
The fourth alternative which was discarded was pedestrian malls. The conversion of streets from vehicle related functions to pedestrian malls was not considered because this strategy was not applicable in suburban areas.

The fifth alternative to be discarded was bicycle lanes and storage facilities. This option was discarded because of the negligible impact that bicycle lanes would have on traffic congestion and CO concentrations.

The final control measure to be dropped was road pricing. This option was dropped because of the difficulty of receiving approval for such a measure in time for implementation by 1987 and because the effects of such a strategy are unknown and difficult to quantify.

EXHIBIT IV-1

PROPOSED PARALLEL FACILITY DEVELOPMENT



SOURCE: Charlotte Department of Engineering

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OVERVIEW OF STRATEGIES

As noted previously, the four types of TCMs initially identified as being potentially applicable to Mecklenburg County hot spot intersections were traffic flow improvements, park-n-ride and fringe parking lots, ridesharing, and improved public transit. Of these, the most applicable TCM to the four specific CO hot spots located in suburban Charlotte is traffic flow improvements. Such measures directly address methods for improving the operation of each intersection and reducing CO levels. The use of park-n-ride, ridesharing, and improved public transit TCMs, while conceptually attractive, is likely to have negligible effects in reducing CO concentrations at the four geographically separated suburban hot spots and may be costly to implement and operate. For these reasons, this analysis focused on using traffic flow improvements to reduce CO levels at the four hot spot intersections.

Three TCM alternatives were generated for analyzing the CO problem at the hot spot intersections. The first alternative is the implementation by 1987 of the Traffic Operations and Safety Improvements for each intersection. These improvements are based on plans already developed by the Charlotte Department of Transportation for increasing the operating efficiency and traffic safety at each intersection. Information on the nature of these improvements was obtained from detailed aerial photographs and engineering drawings for intersection improvements developed by the Department.

The second control strategy considered involves the improvement to two parallel facilities in addition to the improvements to each intersection discussed above. Specifically, the second alternative assumes that Delta Road will be completed to Monroe Road and that Monroe Road will be widened to four lanes between Old Post Road and Sardis Road North (Exhibit IV-1). The primary purpose of this alternative is to divert traffic away from more heavily congested facilities.

The third and final alternative assumes improvements to intersection geometrics and parallel facilities together with the coordination of traffic signals on Sharon Amity Road at its intersections with Albemarle Road and Central Avenue.

Each alternative is more elaborate and costly than the preceding alternative. For this reason, the most appropriate strategy for achieving compliance with the NAAQS 8-hour CO standard is simply the least elaborate alternative for which the CO standard is met.

The details of these alternatives as they pertain to each of the CO hot spot intersections are described in the subsections that follow.

Central Avenue and Sharon Amity Road

The first alternative control strategy for the intersection of Central Avenue and Sharon Amity Road is the Traffic Operations and Safety Improvements already developed by the Charlotte Department of Transportation for this intersection.

This improvement consists of adding another left turn lane to each direction of Central Avenue and adjusting the alignment of the other lanes to accommodate the change. This alternative is shown in Exhibit A-2. This control strategy will help to relieve the congestion expected in 1987 as a result of increased development in the area (see Exhibit A-4).

The second strategy includes strategy one together with improvements to two parallel facilities--Delta Road and Monroe Road. The completion of Delta Road from its present southern terminus across Independence Boulevard to Monroe Road will provide a new circumferential facility in eastern Charlotte. It is estimated that this new route will divert 70 to 80 vehicles per hour (in each direction) from the Sharon Amity Road corridor (Exhibit A-5). The result will be less congestion and reduced CO emissions at the Central Avenue-Sharon Amity Road hot spot.

The third strategy assumes, in addition to the first two alternatives, that the traffic signal at this intersection is coordinated with the controller at the intersection of Albemarle and Sharon Amity Roads. Based on prior experience in the Charlotte area, coordination of signals can be expected to reduce travel time through an intersection by approximately 25

percent.[1] This improvement serves to reduce both the excess travel time and the fraction of vehicles that is forced to stop at each intersection. This, in turn, reduces total CO emissions at the intersection. Since traffic on only one approach to the intersection (Sharon Amity Road from the north) is affected by the coordination, these reductions will be assumed applicable to only that approach.

Albemarle and Sharon Amity Road

The first alternative control strategy for the intersection of Albemarle and Sharon Amity Roads is the Charlotte Department of Transportation's proposed Traffic Operations and Safety Improvements (Exhibit B-2). This improvement will increase intersection capacity by adding an additional left turn lane to each approach of Albemarle Road and reserved right turn lanes to each approach of Sharon Amity Road. The projected 1987 traffic volumes for this alternative are shown in Exhibit B-4.

The second alternative strategy assumes improvements to Delta and Monroe Roads in addition to the first alternative mentioned above. The primary benefit of this improvement is the diversion of 70 to 80 vehicles during the peak hour from Sharon Amity Road (Exhibit B-5).

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[1] Frederick A. Wagner, Overview of the Impacts and Costs of Traffic Control System Improvements, March 1980.

The final alternative includes alternatives one and two together with the coordination of the traffic signal controller at this intersection with the traffic signal controller at the intersection of Central Avenue and Sharon Amity Road. This coordination is expected to reduce travel time by 25.8 percent on the southern approach (Sharon Amity Road).

Independence Boulevard and Sharon Amity Road

The first alternative control strategy for the intersection of Independence Boulevard and Sharon Amity Road is the Traffic Operations and Safety Improvements for that intersection developed by the Charlotte Department of Transportation (Exhibit C-2). This improvement will increase intersection capacity by adding a second left turn lane to all approaches of the intersection except the western approach (Independence Boulevard). A right turn lane will also be added to the two Independence Boulevard approaches. Exhibit C-4 shows the assumed traffic volumes for this strategy.

The second alternative involves improvements to Delta and Monroe Roads in addition to the improvements of the first alternative. As stated previously, the improvement of Delta Road is expected to divert 70 to 80 peak-hour vehicles in each direction from Sharon Amity Road. Furthermore, the Monroe Road widening project is expected to divert 300

westbound and .460 eastbound peak-hour vehicles from Independence Boulevard. The result of this diversion is that all roadways in the corridor operate more efficiently with fewer delays and fewer stopping vehicles. This serves to reduce excess CO emissions at the hot spot intersections (Exhibit C-5).

The third alternative, coordination of the signal controllers at Central Avenue and Sharon Amity Road and at Albemarle and Sharon Amity Roads has no substantial effect on CO concentrations at the intersection of Independence Boulevard and Sharon Amity Road.

Independence Boulevard and Idlewild Road

The first alternative control strategy for the intersection of Independence Boulevard and Idlewild Road involves several geometric improvements to this intersection (Exhibit D-2). These improvements include adding a second through lane to both approaches of Idlewild Road and adding right turn lanes to both approaches of Independence Boulevard. The addition of through lanes on Idlewild Road was already planned by the Charlotte Department of Transportation in its Traffic Operations and Safety Improvements Plan. The 1987 traffic volumes at this intersection projected for this alternative are shown in Exhibit D-4.

The second alternative considered was the improvement of Delta and Monroe Roads together with the intersection geometric improvement described in the first alternative. The completion of Delta Road is expected to divert some traffic now using Idlewild Road to the southern suburbs of Charlotte. It is estimated that 105 westbound and 240 eastbound vehicles will be diverted from Idlewild Road during the peak hour. The widening of Monroe Road is expected to divert traffic from Independence Boulevard as the two facilities are both radial routes feeding the central city. As was the case at the intersection of Independence Boulevard and Sharon Amity Road, between 300 and 460 peak-hour vehicles in each direction will be diverted from Independence Boulevard (Exhibit D-5).

The third alternative involves the coordination of the signal controllers at Albemarle and Sharon Amity Roads and at Central Avenue and Sharon Amity Road. This coordination is not expected to significantly affect CO concentrations at Independence Boulevard and Idlewild Road.

ESTIMATED CO CONCENTRATIONS

The estimated 8-hour CO concentrations in 1987 for each alternative control strategy are presented in Exhibit IV-2. The Albemarle-Sharon Amity Roads and Independence Boulevard-Idlewild Road intersections are in compliance with the NAAQS

EXHIBIT IV - 2

SUMMARY OF 8-HOUR CO CONCENTRATION BY SCENARIO

CO In mg/m^3

Alternative Control Strategy	Central and Sharon Amity	Albemarle And Sharon Amity	Independence And Sharon Amity	Independence And Idlewild
1 - Intersection Operations And Safety Improvements	11.3	9.4	— [1]	7.0
2 - Intersection And Parallel Facility Improvements	11.2	8.3	8.5	7.3
3 - Coordinated Signals Plus Strategy 2 Above	10.5	—	—	—

[1] Capacity of intersection exceeded, CO is likely over EPA 8-hour standard.

8-hour standard by implementing Charlotte's proposed Intersection Operations and Safety Improvements. Implementation of the second alternative, parallel roadway improvements, brings the Independence Boulevard-Sharon Amity Road intersection into compliance. However, neither strategy one nor two are sufficient to bring the Central Avenue-Sharon Amity Road intersection into compliance.

CAPITAL COST ESTIMATES

The estimated capital costs for the TCMs described above are:

Location	Capital Cost (in 1982 dollars)*
Central and Sharon Amity Improvements	$ 161,000
Sharon Amity and Albemarle Improvements	320,000
Independece and Sharon Amity Improvements	530,000@
Monroe Road Widening	3,846,000
Sharon Amity Signal System	180,000

* Estimates were prepared by City of Charlotte Engineering Department.

@ Excludes construction of right turn lanes on Independence Boulevard which have been constructed by NCDOT.

V. SUMMARY

The Volume 9 procedure, when modified to accept MOBILE 2 emission factors, estimates CO concentrations that compare favorably with both Engineering Science's estimates and measured worst case 8-hour CO concentrations. When this model is used to forecast CO levels in 1987, two intersections (Albemarle-Sharon Amity and Independence-Idlewild) show CO concentrations less than the NAAQS 8-hour standard when traffic operation and safety improvement plans already specified by the City of Charlotte are implemented. One other intersection (Independence Boulevard-Sharon Amity Road) meets the NAAQS standard when the planned Delta Road extension and the Monroe Road widening are completed. The final hot spot intersection (Central Avenue-Sharon Amity Road) does not meet NAAQS standards under any control strategy yet analyzed.

APPENDIX A

GEOMETRIC AND TRAFFIC VOLUME DATA USED FOR ANALYSIS OF CENTRAL AVENUE AND SHARON AMITY ROAD

EXHIBIT A-1

CURRENT CONDITIONS FOR INTERSECTION OF CENTRAL AVENUE AND SHARON AMITY ROAD

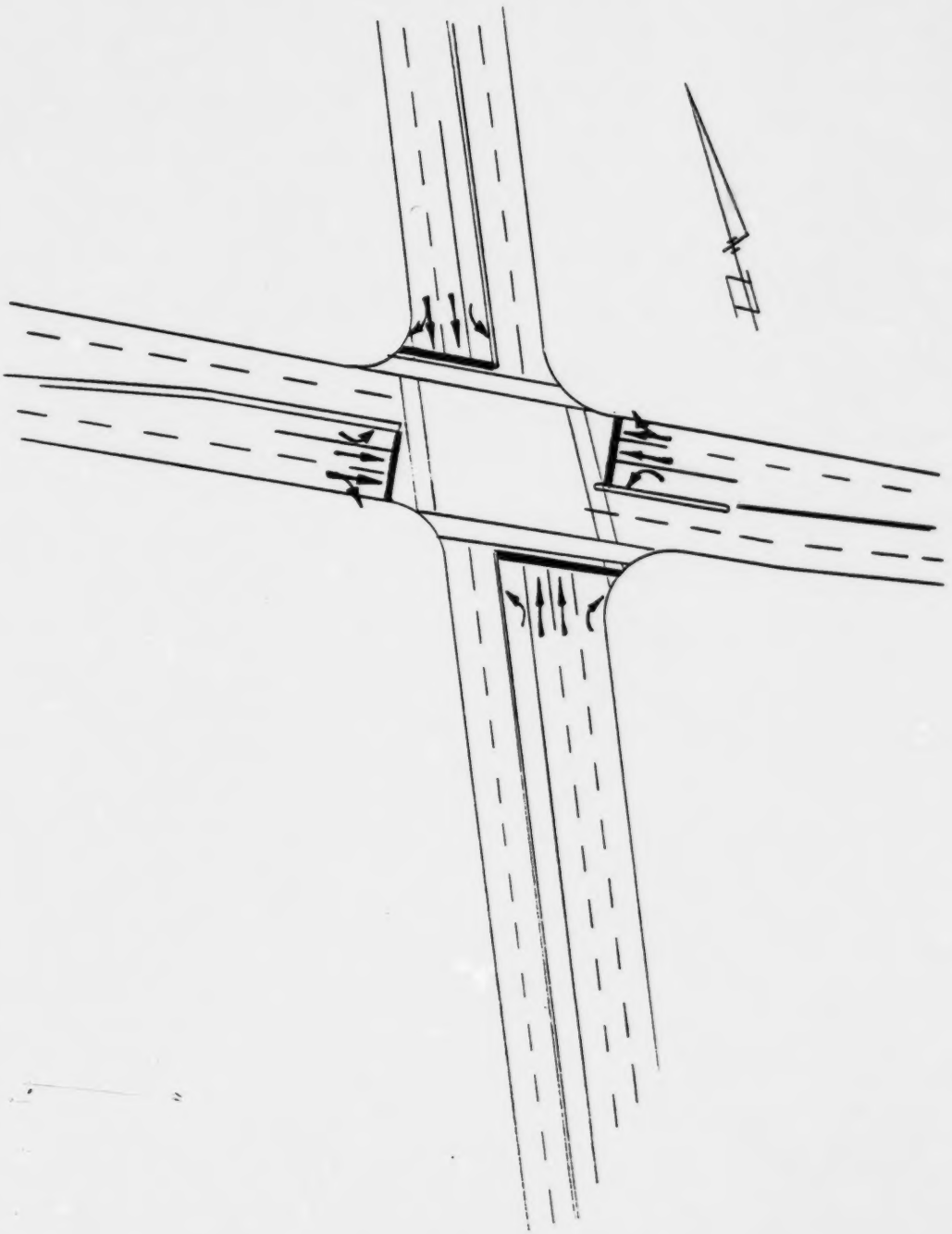
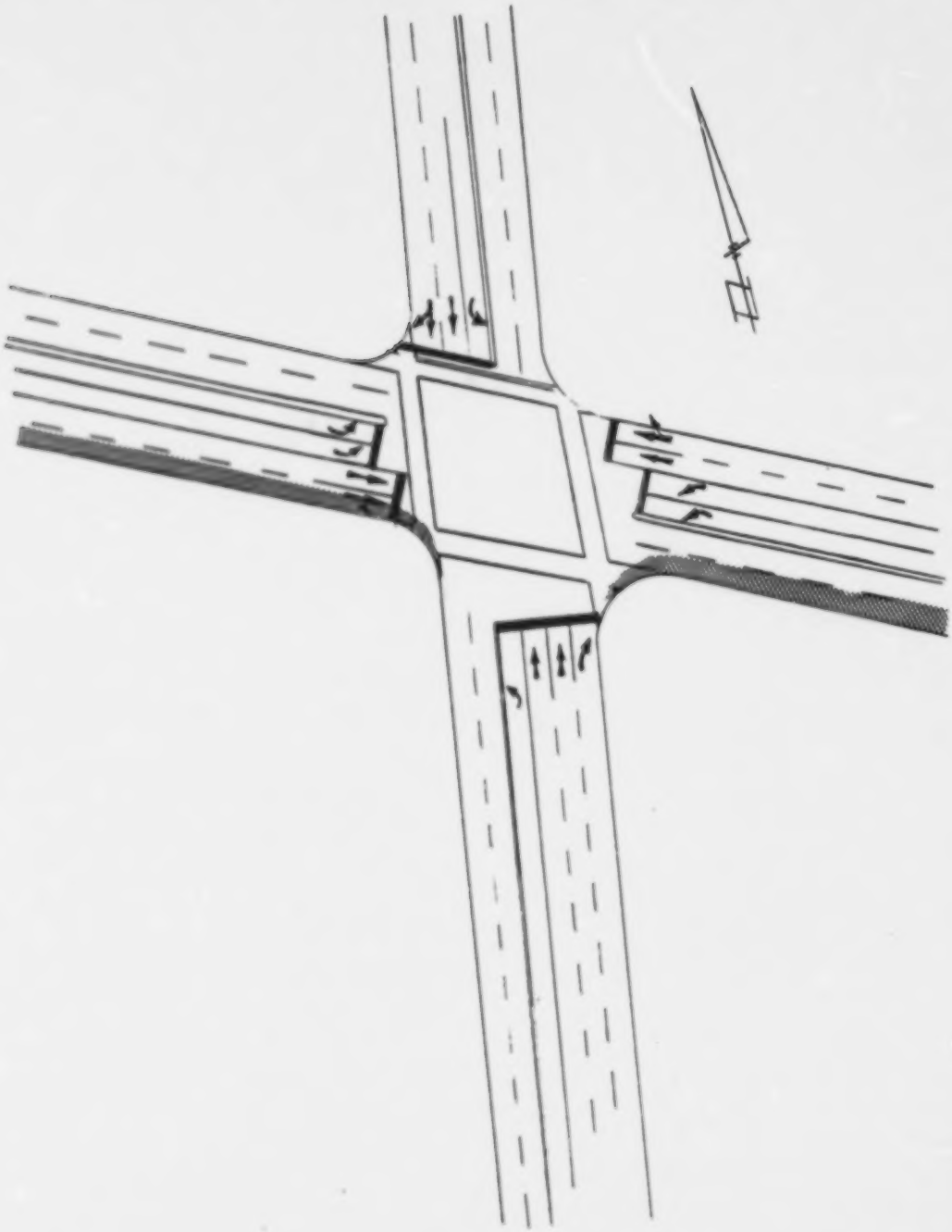


EXHIBIT A-2

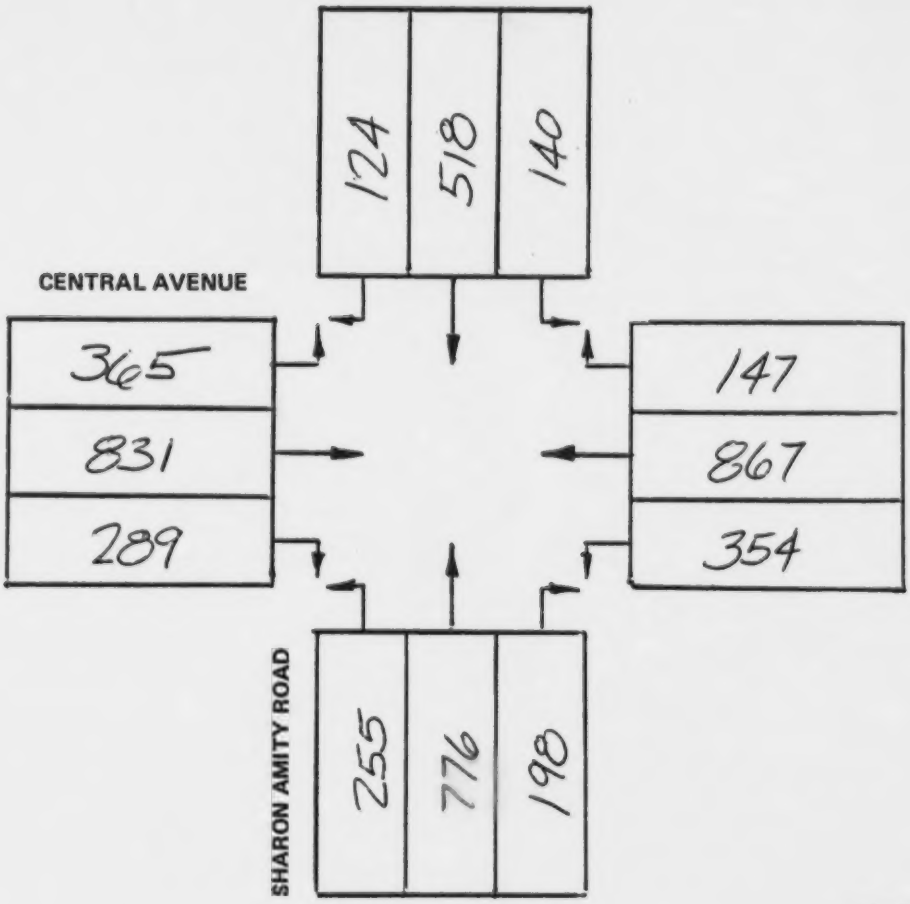
ALTERNATIVE 1 GEOMETRICS FOR INTERSECTION OF CENTRAL AVENUE AND SHARON AMITY ROAD



NOTE: Shaded Areas Indicate Extent of Additional Pavement

EXHIBIT A-3

1980 PEAK HOUR TRAFFIC VOLUME
CENTRAL AVENUE AND SHARON AMITY ROAD



SOURCE: Charlotte Department of Transportation

EXHIBIT A-4

1987 PEAK HOUR TRAFFIC VOLUME
CENTRAL AVENUE AND SHARON AMITY ROAD
Alternative 1, Geometric Improvements to Intersections

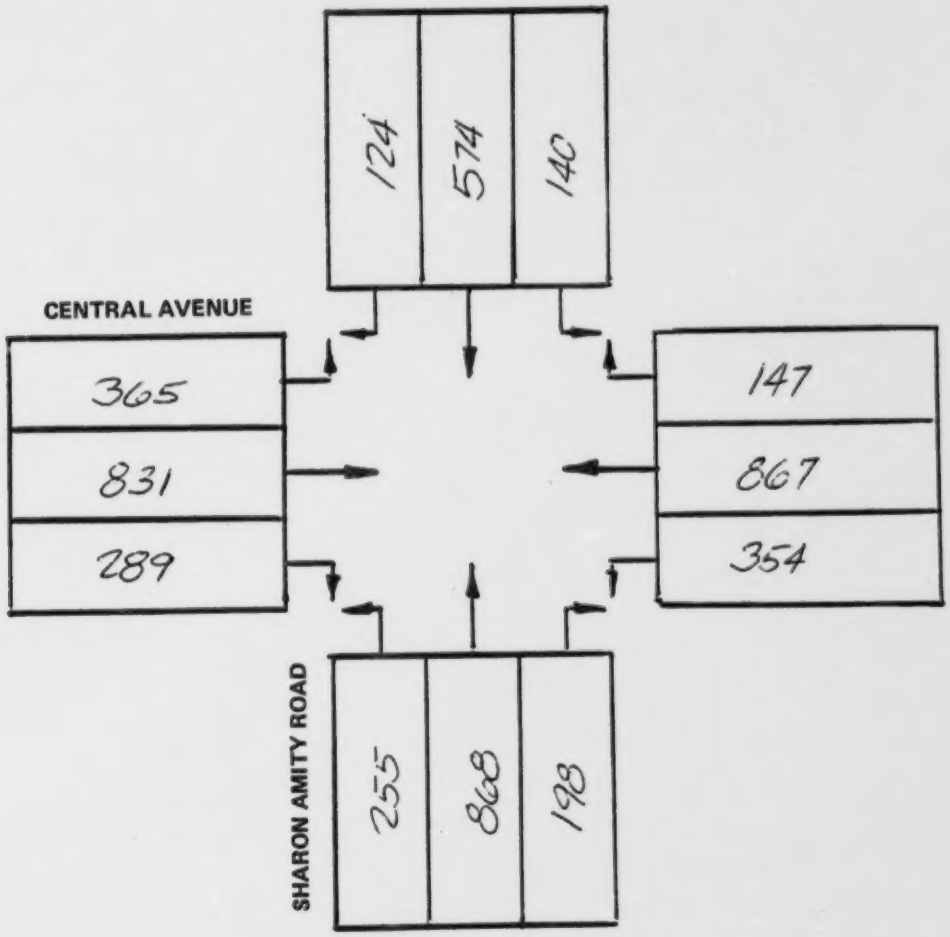
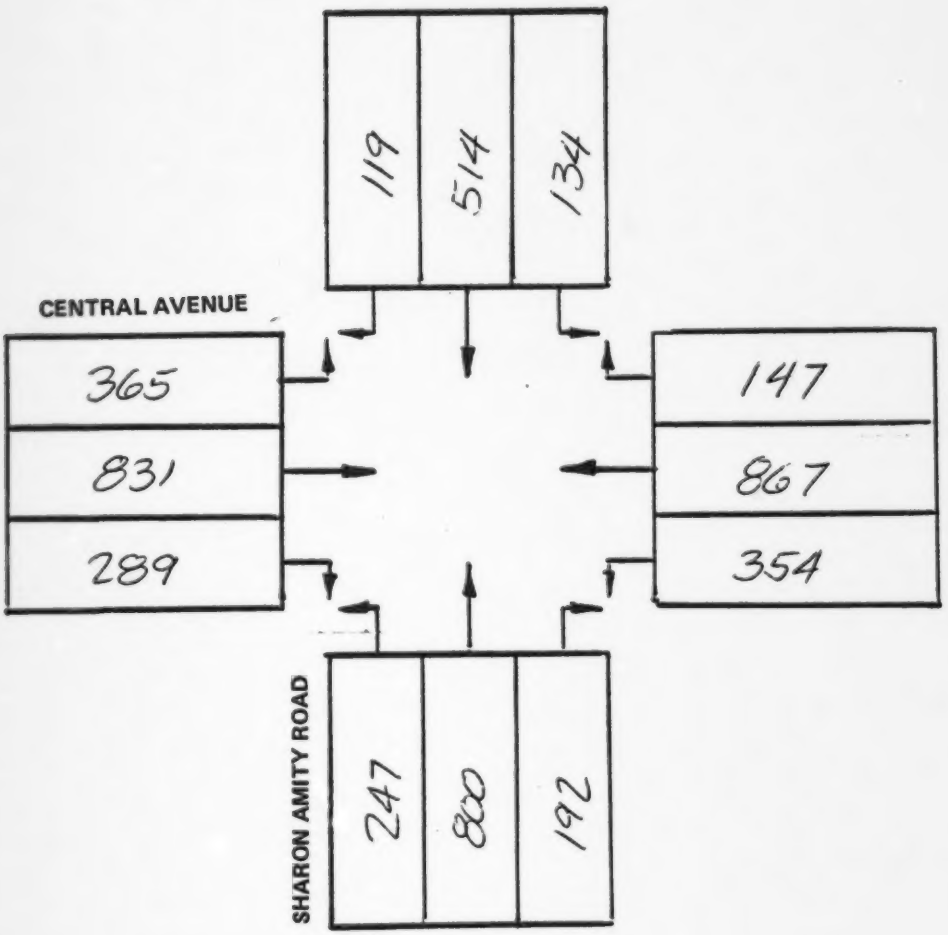


EXHIBIT A-5

1987 PEAK HOUR TRAFFIC VOLUME
CENTRAL AVENUE AND SHARON AMITY ROAD
Alternative 2, Parallel Facility Improvements and
Alternative 3, Coordinated Signal System



APPENDIX B

GEOMETRIC AND TRAFFIC VOLUME DATA USED FOR INTERSECTION OF ALBEMARLE ROAD AND SHARON AMITY ROAD

EXHIBIT B-1

PRESENT GEOMETRIC CONDITIONS AT ALBEMARLE ROAD AND SHARON AMITY ROAD

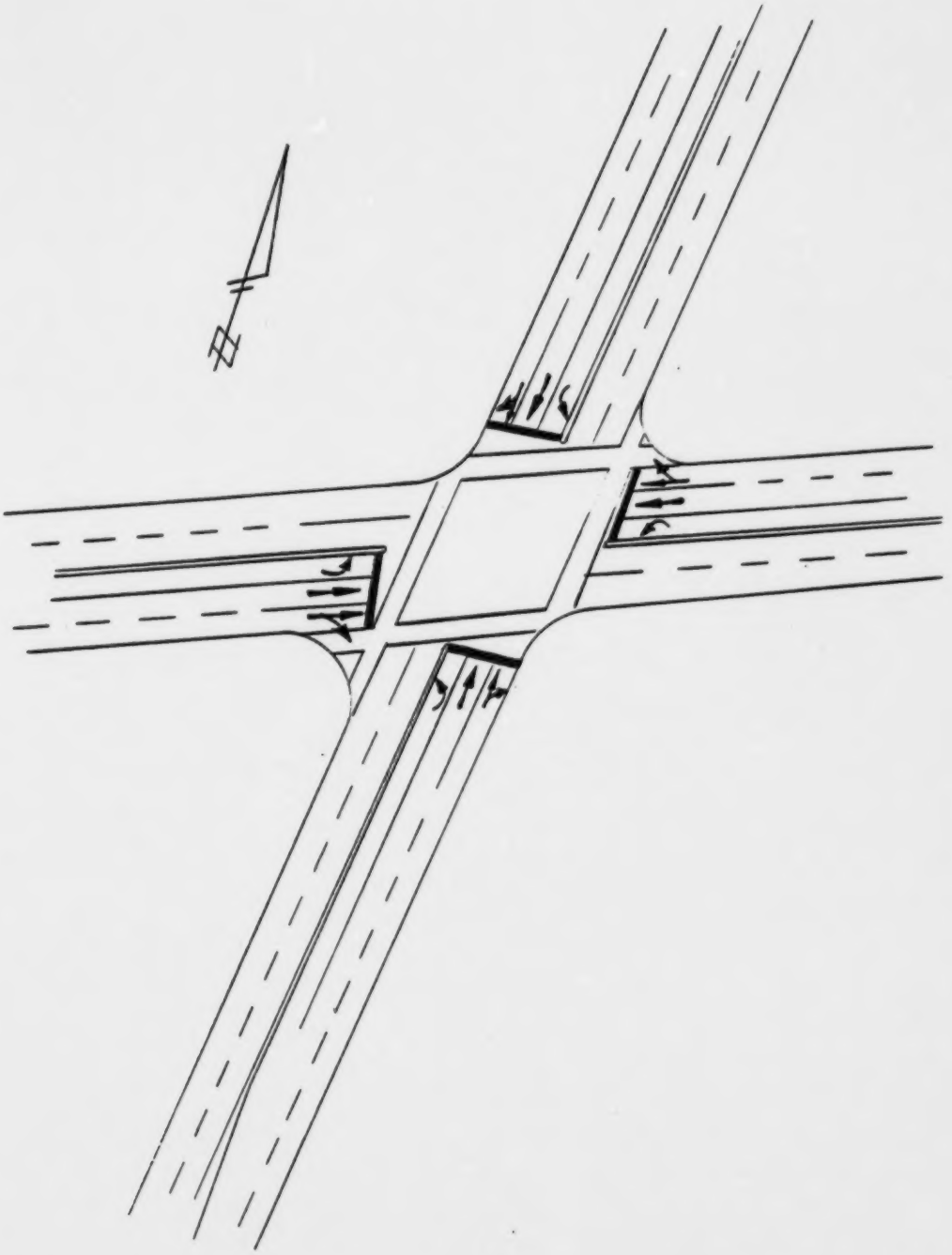
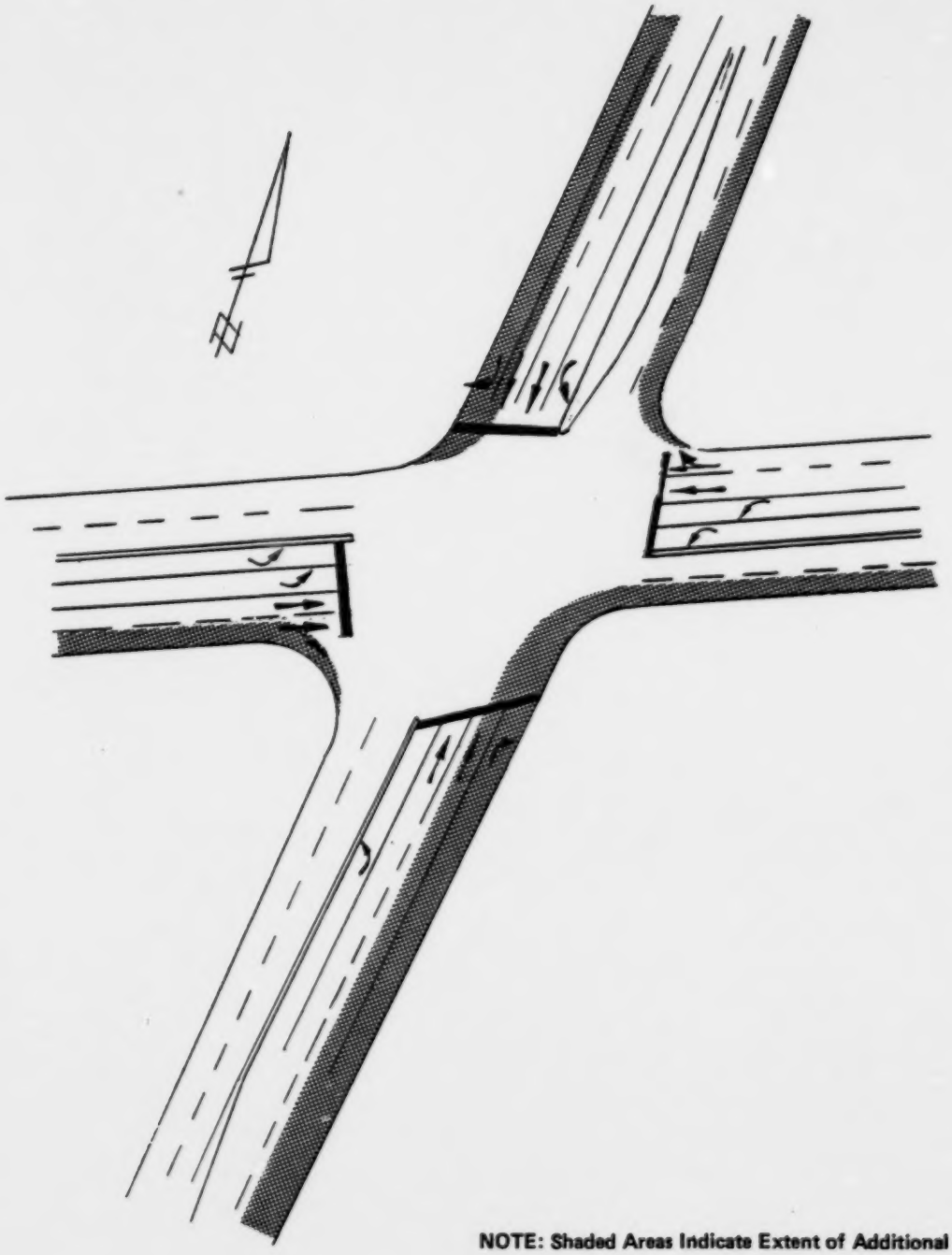


EXHIBIT B-2

GEOMETRIC CONDITIONS FOR ALTERNATIVE 1 AT ALBEMARLE ROAD AND SHARON AMITY ROAD



NOTE: Shaded Areas Indicate Extent of Additional Pavement

EXHIBIT B-3

1980 PEAK HOUR TRAFFIC VOLUME
ALBEMARLE ROAD AND SHARON AMITY ROAD

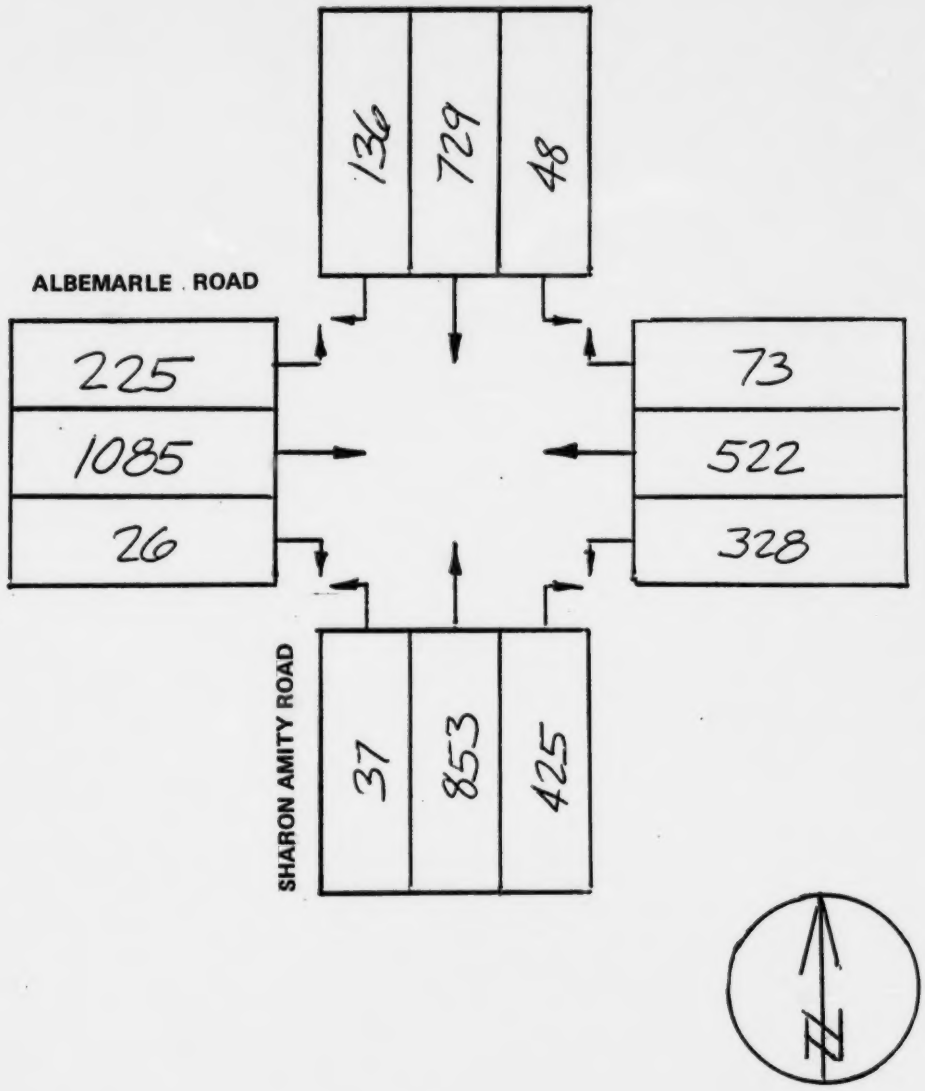


EXHIBIT B-4

1987 PEAK HOUR TRAFFIC VOLUME
ALBEMARLE ROAD AND SHARON AMITY ROAD
Alternative 1, Geometric Improvements to Intersections

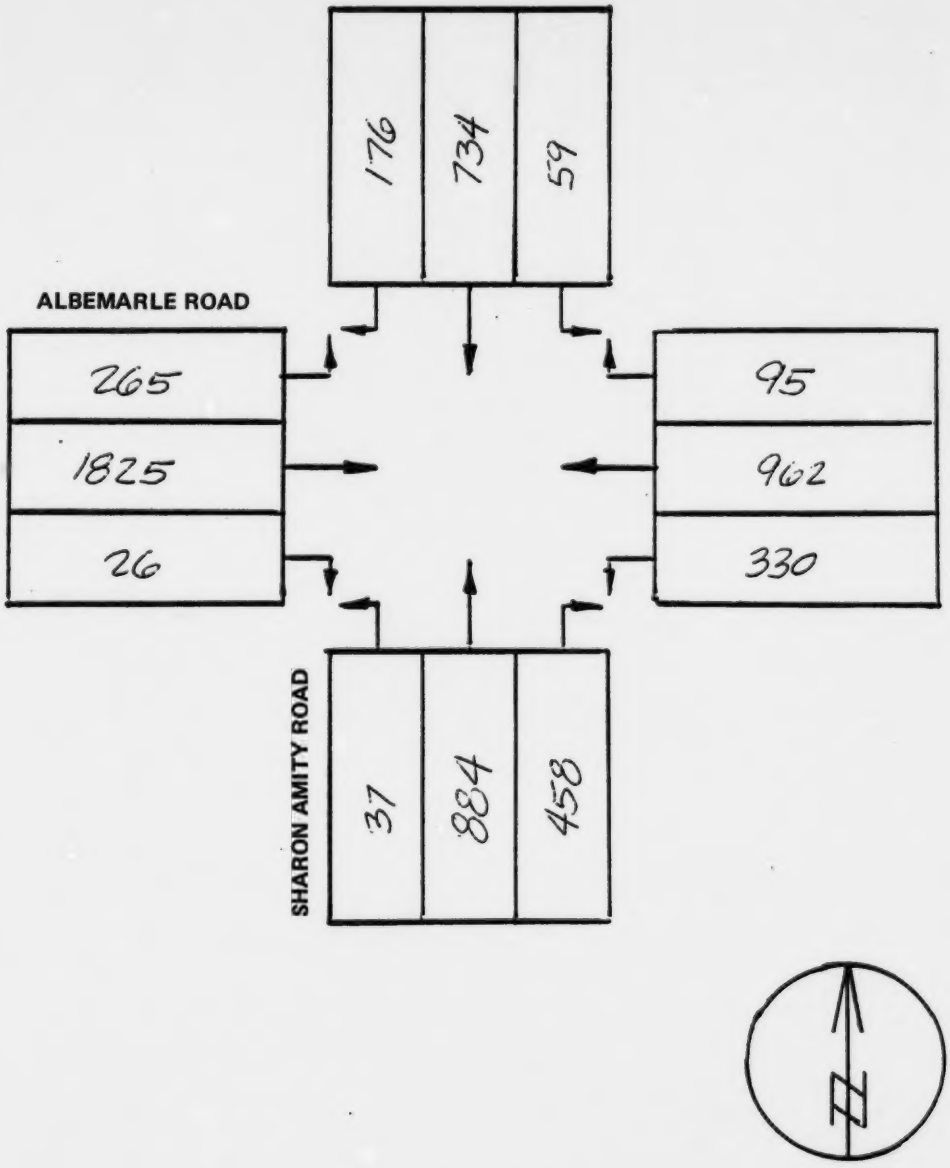
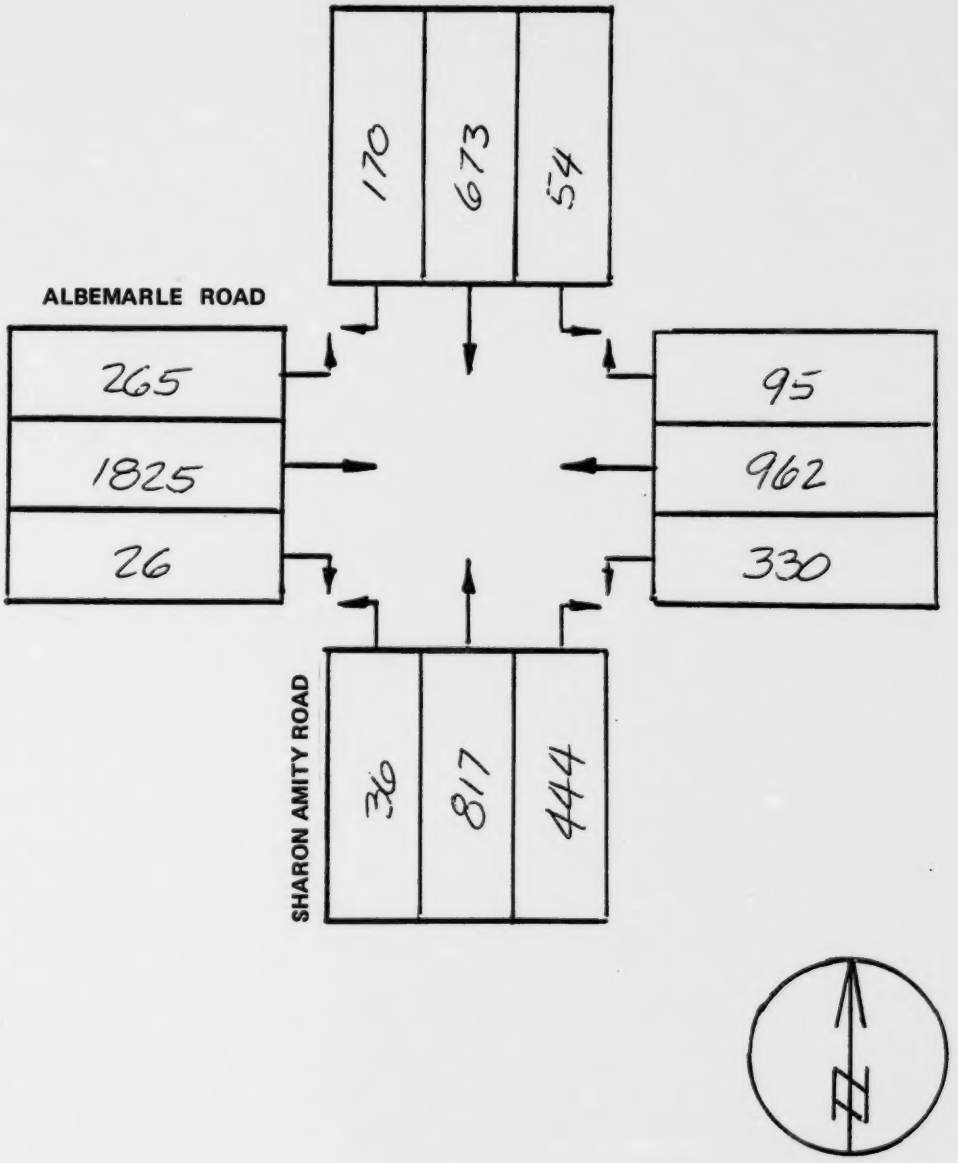


EXHIBIT B-5

1987 PEAK HOUR TRAFFIC VOLUME
ALBEMARLE ROAD AND SHARON AMITY ROAD
Alternative 2, Parallel Facility Improvements and
Alternative 3, Coordinated Signal System



APPENDIX C

GEOMETRIC AND TRAFFIC VOLUME DATA USED FOR INTERSECTION OF INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD

EXHIBIT C-1

CURRENT GEOMETRIC CONDITIONS AT INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD

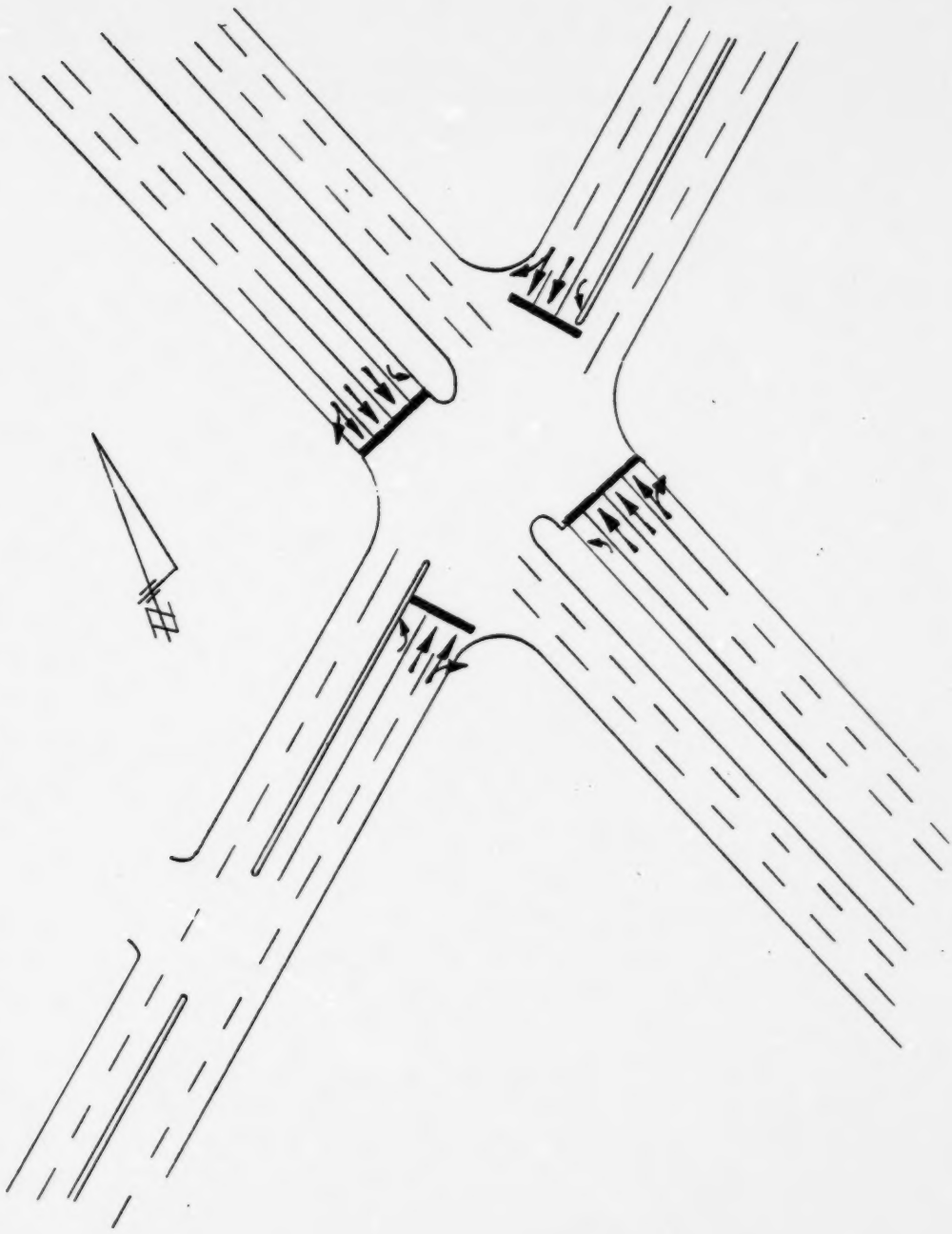
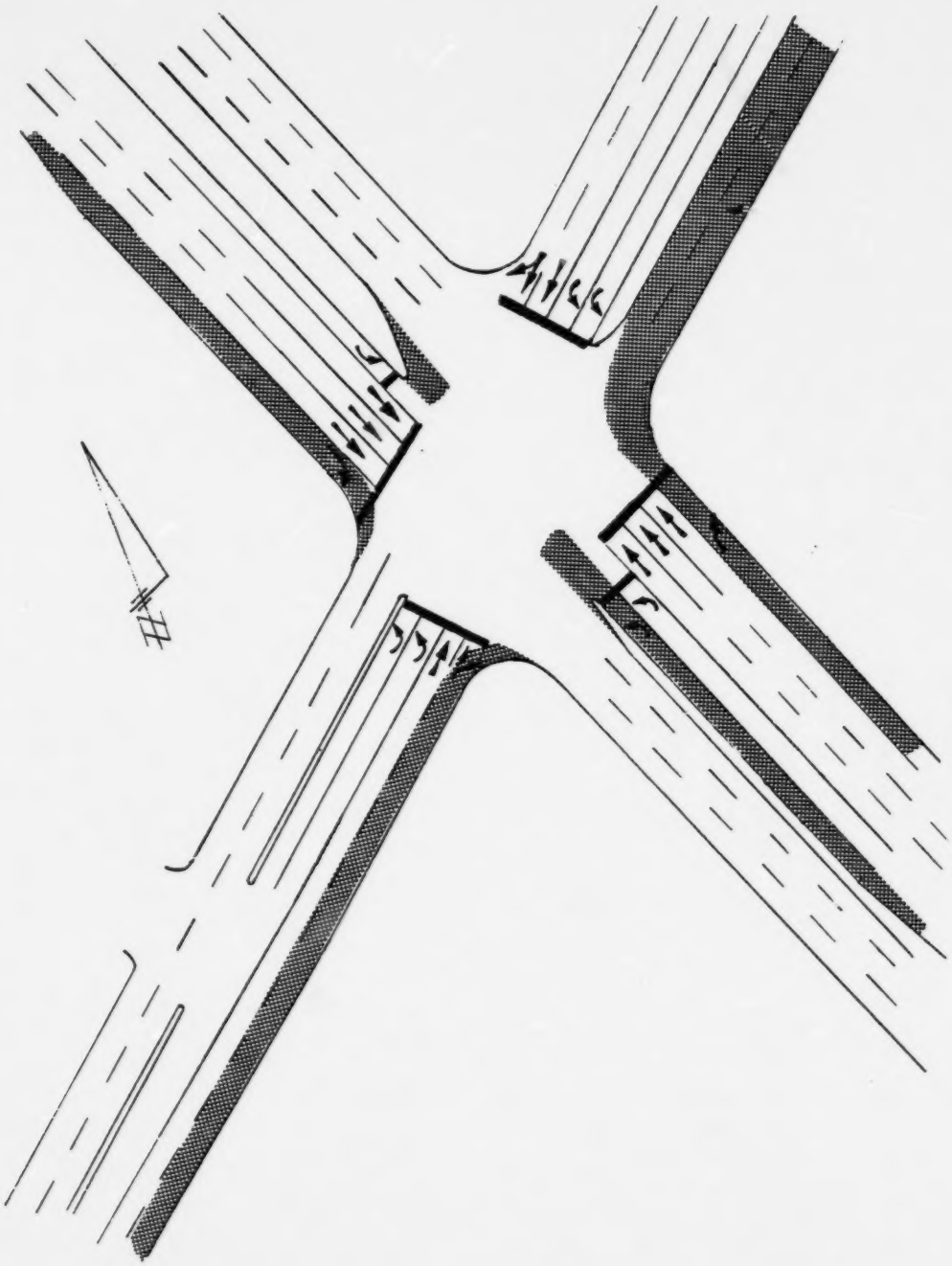


EXHIBIT C-2

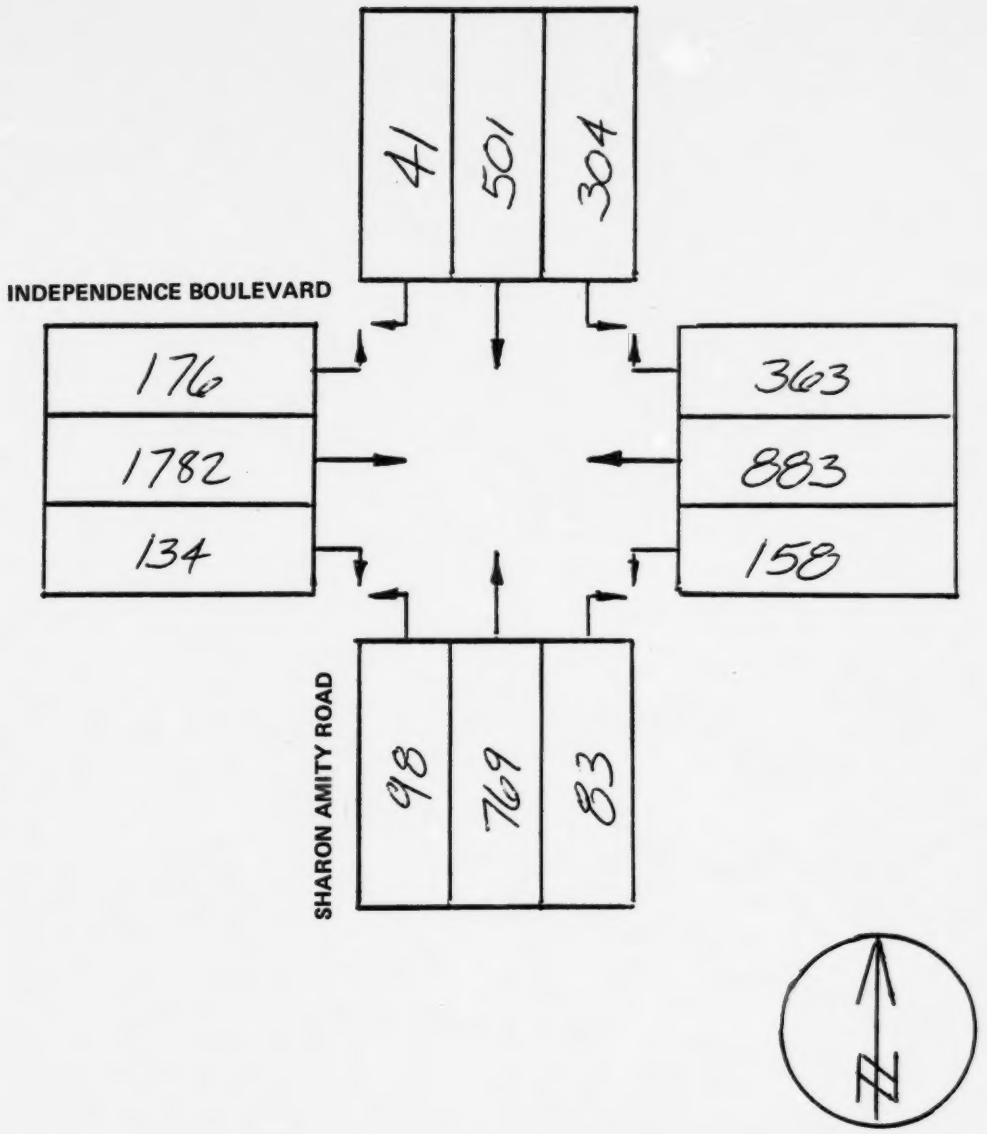
GEOMETRIC CONDITIONS FOR ALTERNATIVE 2 AT INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD



NOTE: Shaded Areas Indicate Extent of Additional Pavement

EXHIBIT C-3

1980 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD



SOURCE: Charlotte Department of Transportation

EXHIBIT C-4

1987 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD
Alternative 1, Geometric Improvements to Intersections

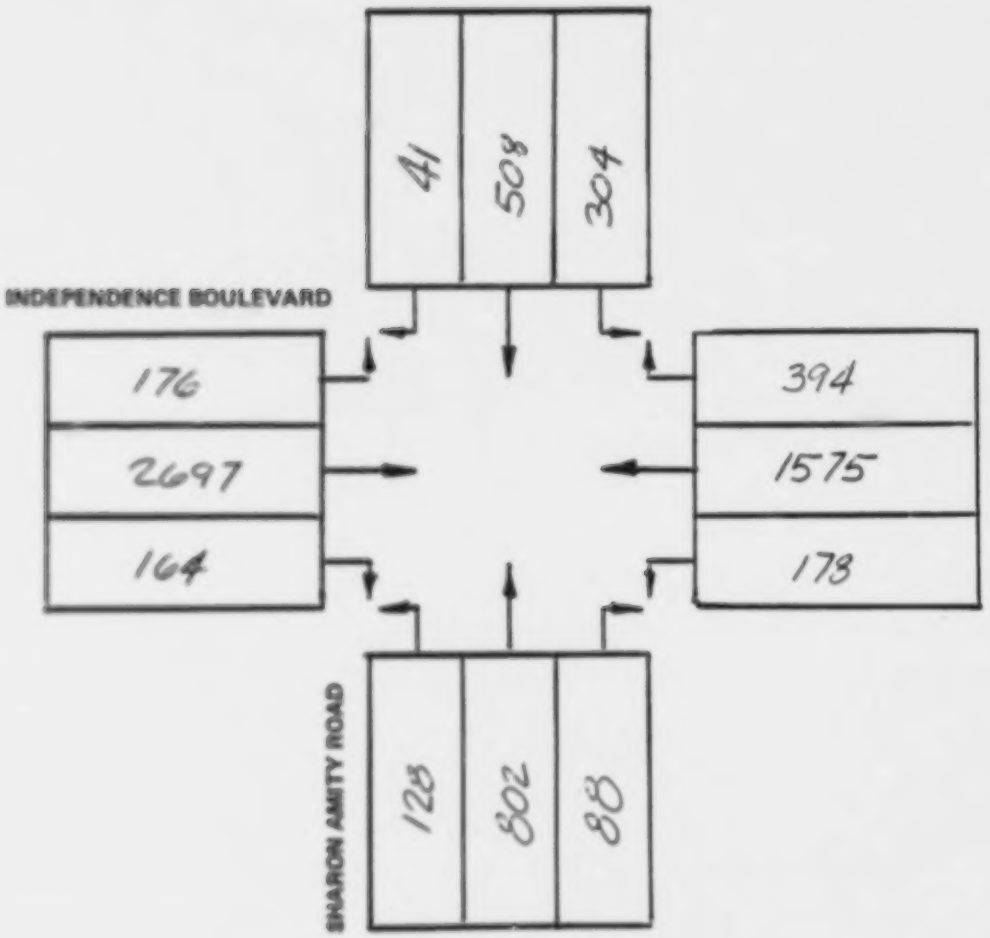
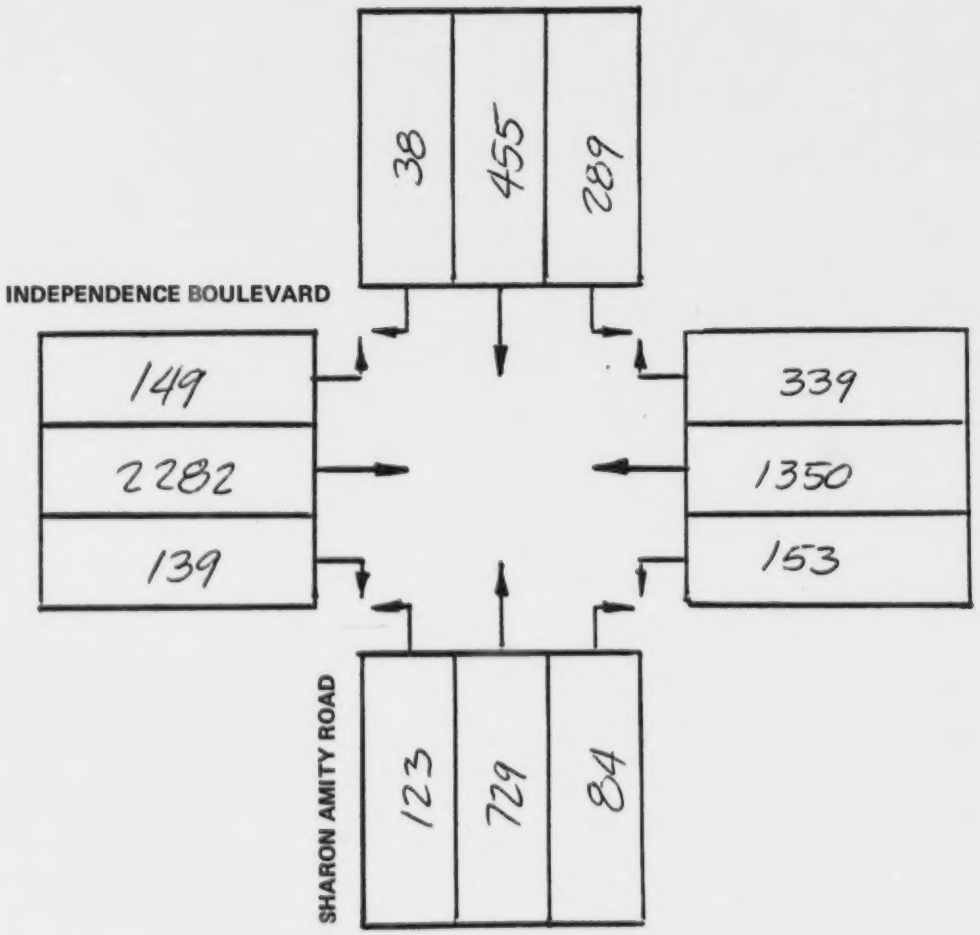


EXHIBIT C-5

1987 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND SHARON AMITY ROAD
Alternative 2, Parallel Facility Improvements
and Alternative 3, Coordinated Signal System



APPENDIX D

GEOMETRIC AND TRAFFIC VOLUME DATA USED FOR INTERSECTION OF INDEPENDENCE BOULEVARD AND IDLEWILD ROAD

EXHIBIT D-1

PRESENT GEOMETRIC CONDITIONS AT INDEPENDENCE BOULEVARD AND IDLEWILD ROAD

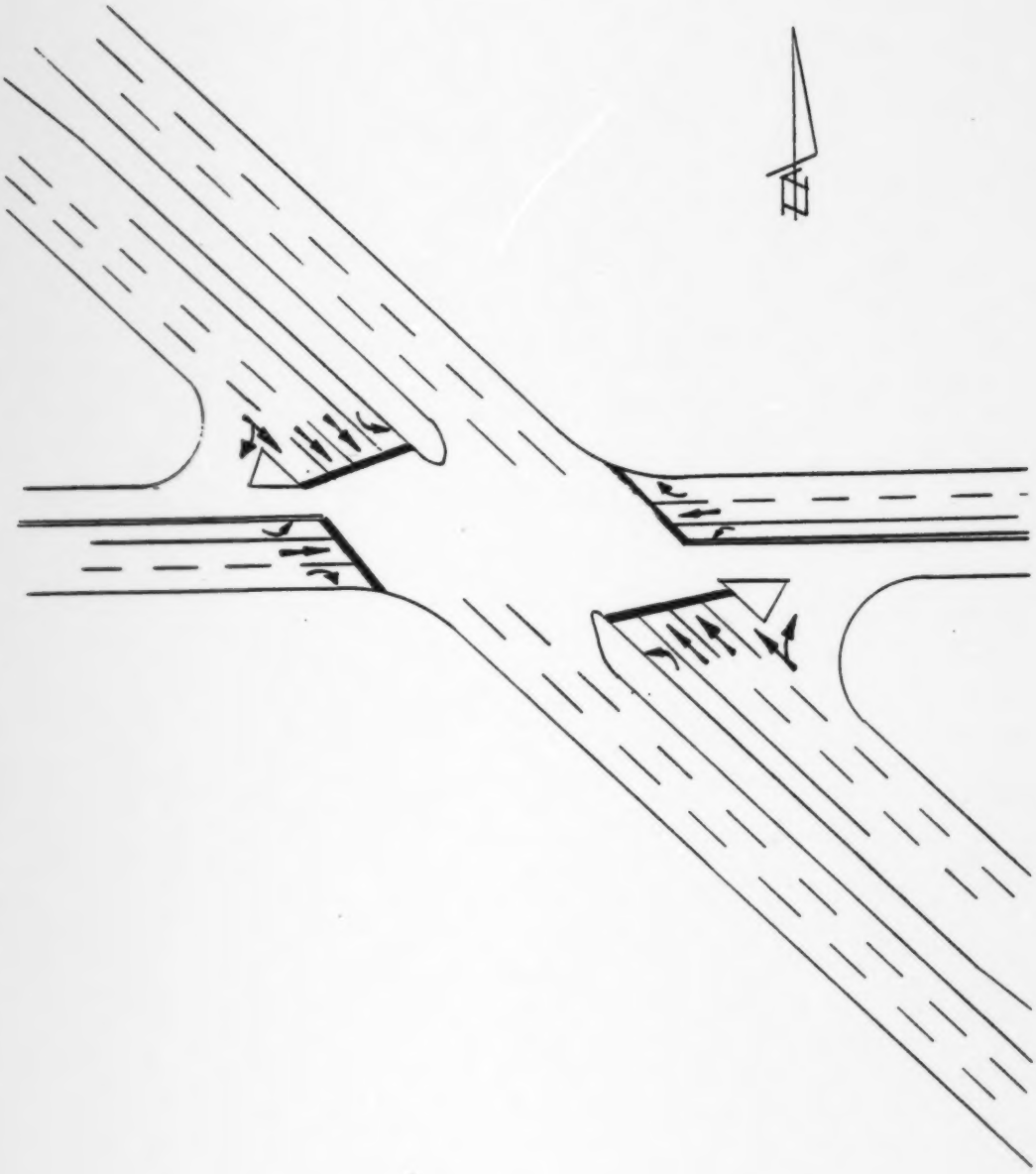
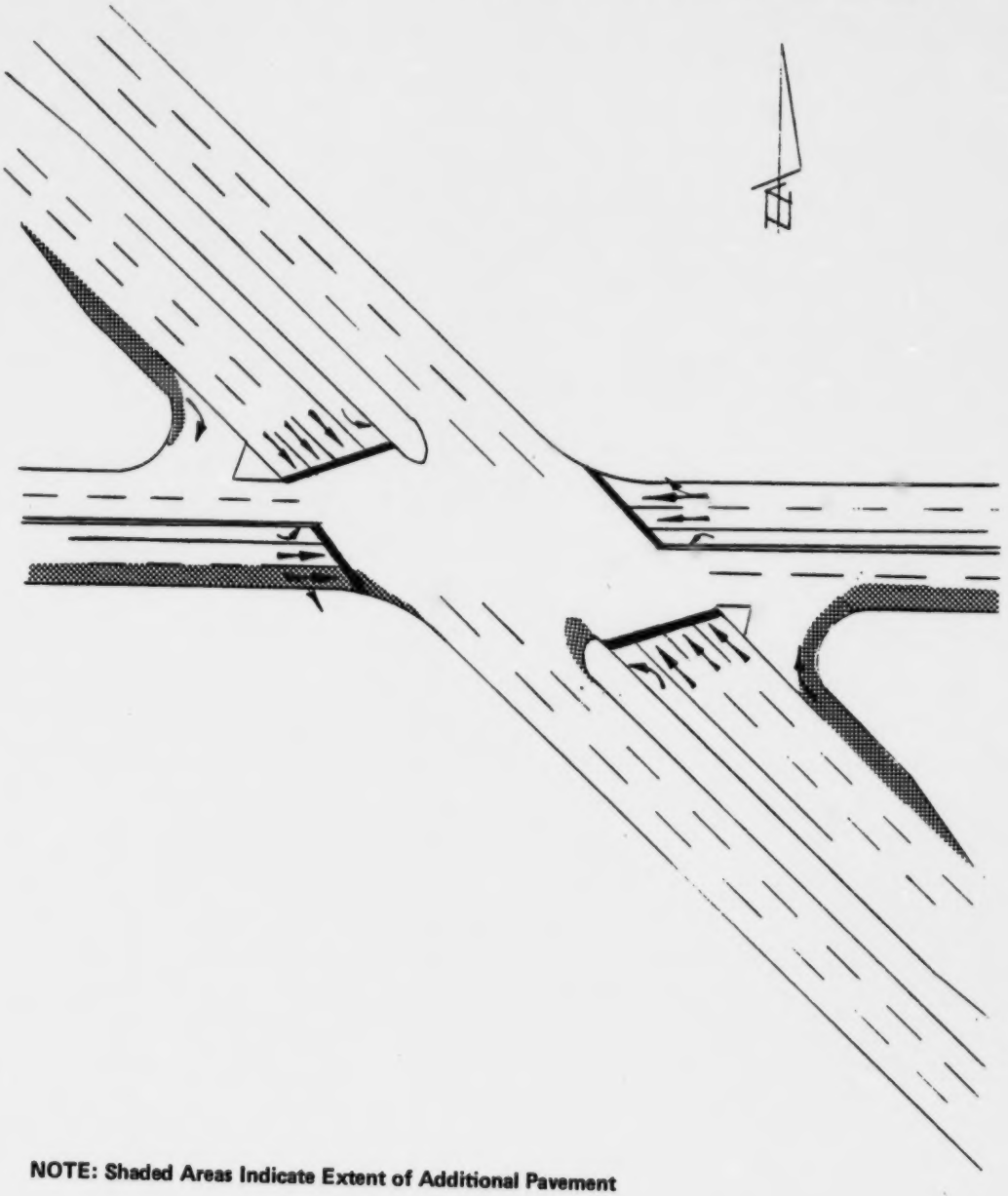


EXHIBIT D-2

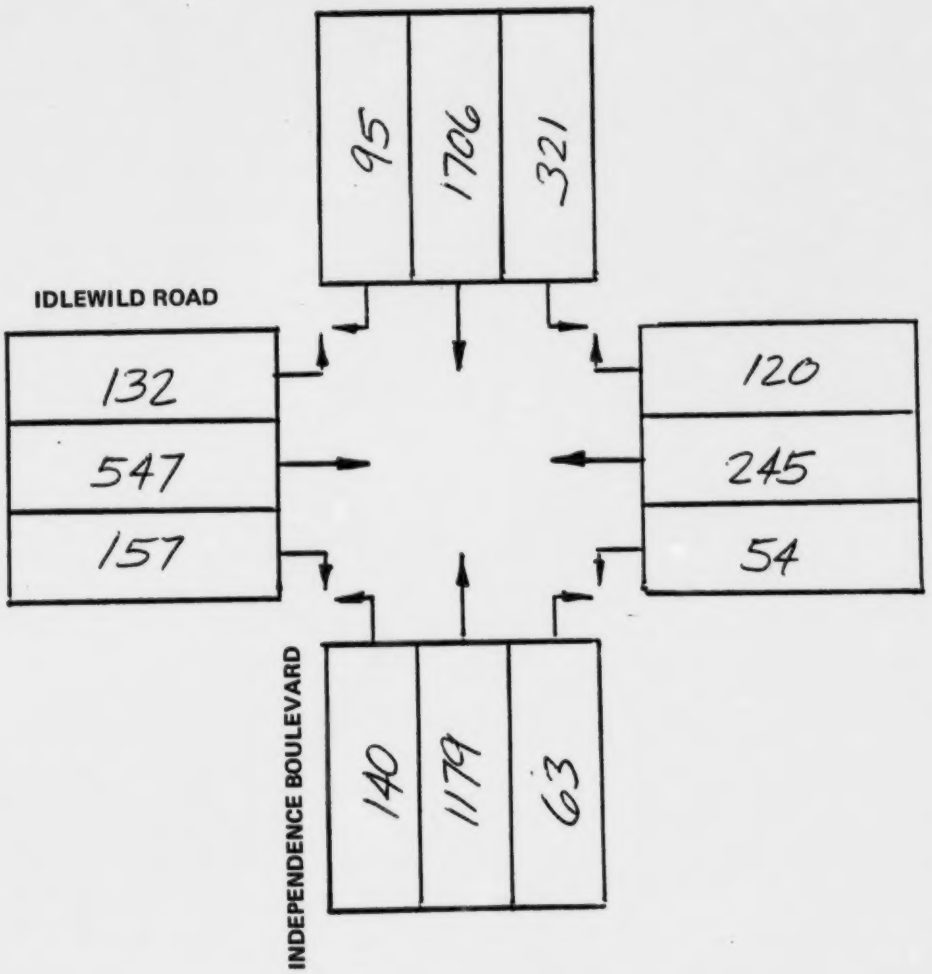
GEOMETRIC CONDITIONS FOR ALTERNATIVE 1 AT INDEPENDENCE BOULEVARD AND IDLEWILD ROAD



NOTE: Shaded Areas Indicate Extent of Additional Pavement

EXHIBIT D-3

1980 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND IDLEWILD ROAD



SOURCE: Charlotte Department of Transportation

EXHIBIT D-4

1987 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND IDLEWILD ROAD
Alternative 1, Geometric Improvements to Intersection

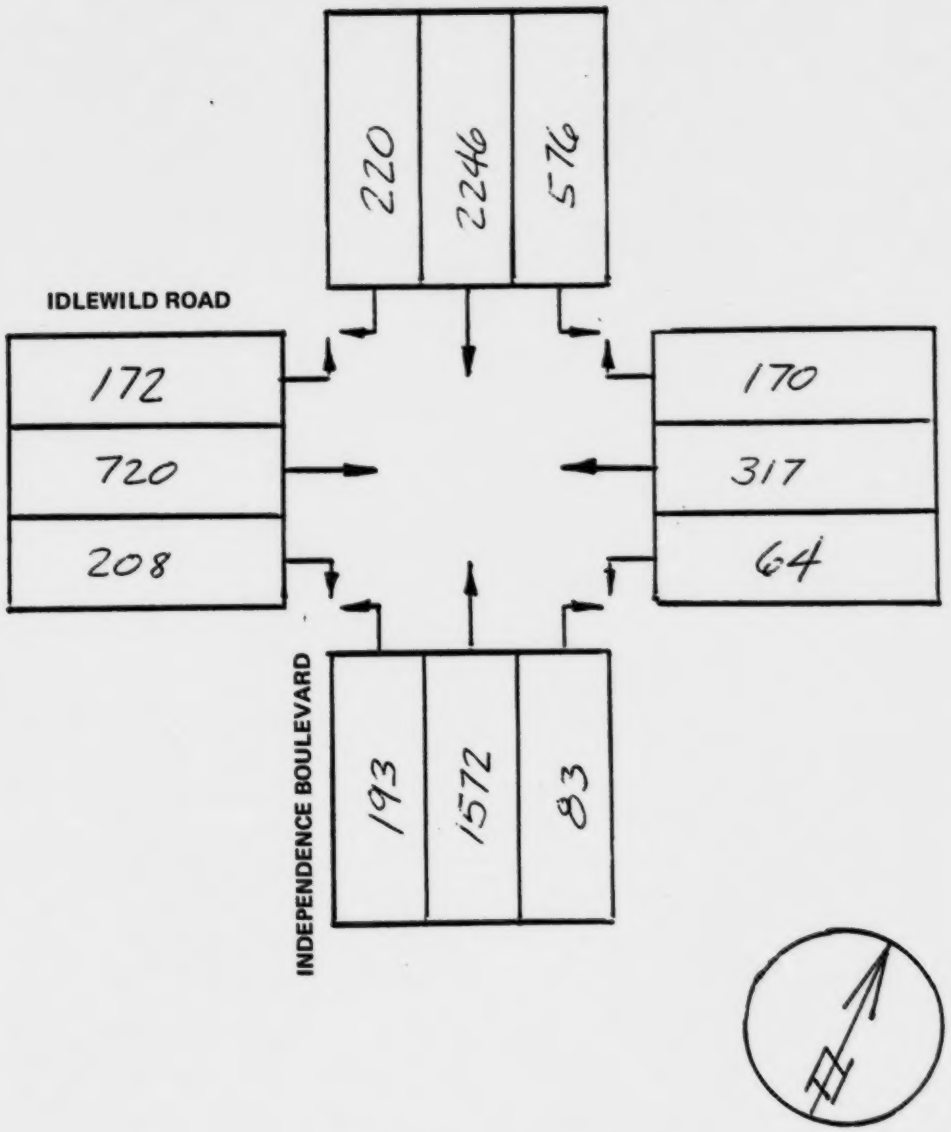
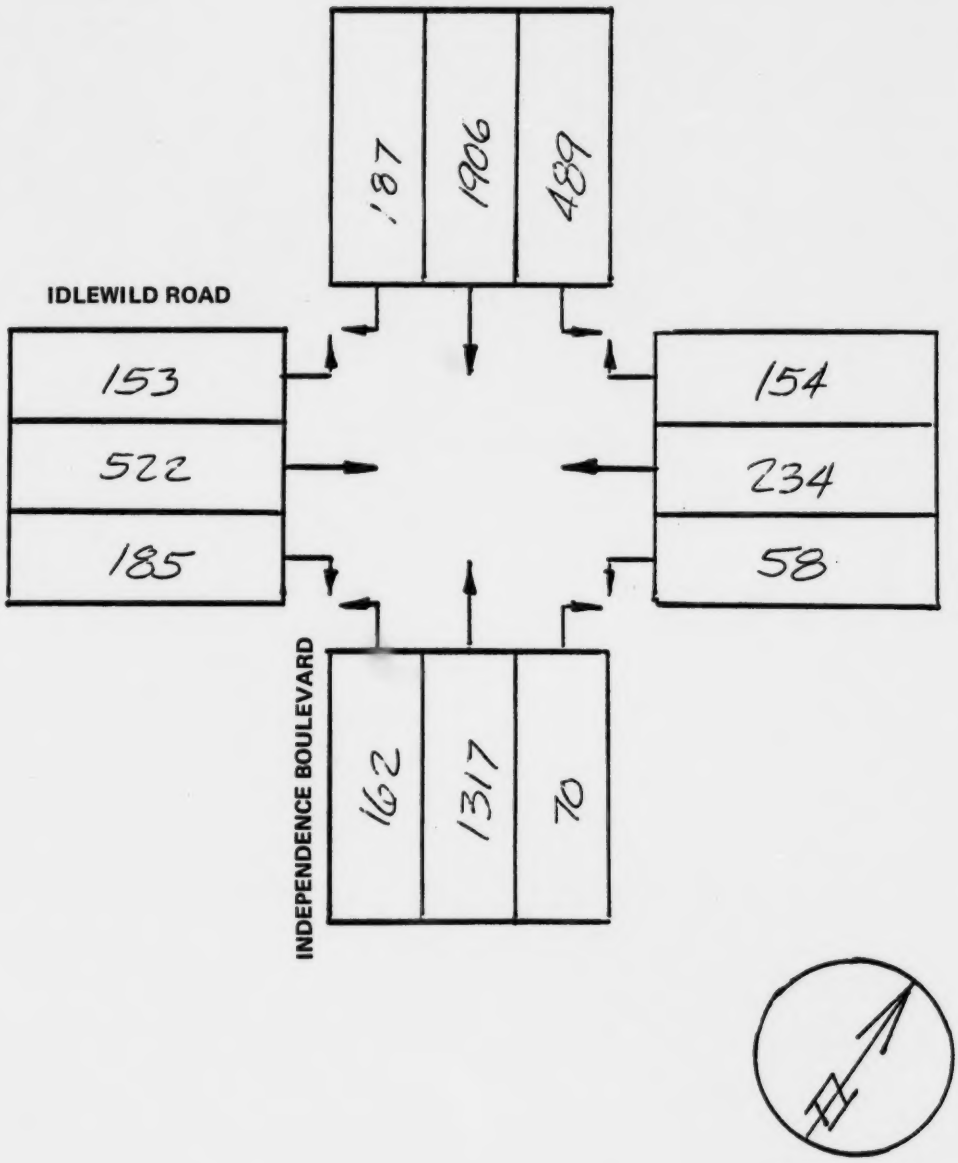


EXHIBIT D-5

1987 PEAK HOUR TRAFFIC VOLUME
INDEPENDENCE BOULEVARD AND IDLEWILD ROAD
Alternative 2, Parallel Facility Improvements and
Alternative 3, Coordinated Signal System



APPENDIX E

REVIEW OF TRANSPORTATION CONTROL MEASURES

TECHNICAL MEMORANDUM

TASK 1: REVIEW OF TRANSPORTATION CONTROL MEASURES

for

WORK ASSIGNMENT 3:

ANALYSIS OF TRANSPORTATION CONTROL MEASURES
FOR ATTAINMENT OF NATIONAL AMBIENT AIR QUALITY STANDARDS

Prepared for

U.S. Environmental Protection Agency

and

Charlotte-Mecklenburg County
Transportation Advisory Committee

Prepared by

Peat, Marwick, Mitchell & Co.
1990 K Street, N.W.
Washington, D.C. 20006

under EPA Contract 68-02-3506

December 15, 1980

REVIEW OF TRANSPORTATION CONTROL MEASURES

This technical memorandum presents Peat, Marwick, Mitchell & Co.'s (PMM&Co.) review of transportation control measures (TCMs) for the Charlotte-Mechlenburg County region. This memorandum has been prepared for Work Assignment No. 3 under EPA Contact No. 68-02-3506. The work assignment is entitled "Analysis of Transportation Control Measures for Attainment of National Ambient Air Quality Standards in Mechlenburg County, N.C." This memorandum documents Task 1 of the Work Plan.

INTRODUCTION

The Charlotte-Mecklenburg County region is required to develop a program of locally implemented TCMs to attain the National Ambient Air Quality Standards for carbon monoxide by 1987. Section 108(F) of the Clean Air Act includes a list of strategies which are readily available measures for attaining the air quality standards. Nineteen types of TCMs have been identified for potential implementation. The objectives of this memorandum are: (1) to evaluate each TCM type in terms of its applicability at addressing carbon monoxide problems and its impact potential, and (2) to select and order those which are the most appropriate in addressing hot spot problems. This memorandum presents the results of PMM&Co.'s review as well as a discussion of the rationale leading to the section and ordering of the TCMs.

THE CURRENT STATUS OF SECTION 108(F) STRATEGIES IN MECKLENBURG COUNTY

One of the nineteen measures which would reduce transportation related emissions is beyond the scope of this study. This is the motor vehicle inspection and maintenance program, which is scheduled for implementation in Mecklenburg County in 1981. The program will be implemented and operated by the Division of Motor Vehicles.

The remaining eighteen TCM types that have been identified for consideration in this study are listed in Exhibit 1. Of these, six have been implemented in the Charlotte-Mecklenburg County region:

- Improved Public Transit,
- Park-n-Ride,
- Employer-Based Ridesharing,
- Areawide Carpool Program,
- Traffic Flow Improvements, and
- Bicycle Lane.

EXHIBIT 1

CHARLOTTE-MECKLENBURG COUNTY TCM STRATEGIES

1. Vapor Recovery Program
2. Improved Public Transit
3. Exclusive Bus and Carpool Lanes
4. Areawide Carpool Programs
5. Private Car Restrictions
6. Long-Range Transit Improvements
7. On-Street Parking Controls
8. Park-n-Ride and Fringe Parking Lots
9. Pedestrian Malls
10. Employer-Based Ridesharing
11. Bicycle Lanes and Storage Facilities
12. Staggered Work Hours
13. Road Pricing
14. Vehicle Idling Controls
15. Traffic Flow Improvements
16. Alternative Fuels or Engines
17. Vehicle Retofit
18. Cold Start Emissions Reduction

Programs for improved public transit are the responsibility of the Transit Planning Office (TPO), which administers the Charlotte Transit System. Recent innovations include express bus services and a downtown free fare zone. The express bus services operate from existing park-n-ride logs. Other programs are scheduled for implementation as part of the TPO's Transit Development Program. An employer-based ridesharing program was initiated for city and county employees in 1978. It has since been expanded to a county-wide car-pooling program, funded by the North Carolina Department of Commerce. Traffic flow improvements have been made by interconnecting traffic signals on arterial streets. The Charlotte-Mecklenburg Transportation Improvement Program includes a list of fourteen additional arterials where the signals will be interconnected. These projects will be implemented by the Charlotte Traffic Engineering Department. Charlotte also has a radial bicycle lane.

The applicability of the remaining TCM types in the Charlotte-Mecklenburg County region will be determined after further study by local agencies. Exhibit 2 identifies the current and future status of each TCM type in the region.

INITIAL SCREENING OF TCMs

The first step in the selection process was to determine which TCMs are generally applicable in addressing CO hot spot problems. It was determined that six of the TCMs are less applicable for solving CO hot spot problems than the remaining strategies. These measures and the reasons they were deemed less applicable are described below. All six can be eliminated without jeopardizing the ability to attain the National Ambient Air Quality Standard.

A Vapor Recovery Program aimed at fuel storage and transfer facilities is not applicable for solving CO hot spot problems. Such a program could reduce the amount of hydrocarbons emitted into the atmosphere at fuel facilities, but would have no impact on CO emissions. This is also a stationary source strategy, not a mobile source strategy. This task is an evaluation of strategies aimed at reducing mobile source emissions.

A strategy of Long-Range Transit Improvements was removed from the list since it is highly unlikely that the air quality impacts of any high-capital transportation project (i.e., heavy or light-rail transit, busways) not presently in the design, engineering, or construction stage could be realized prior to the 1987 air quality compliance deadline. Such is the case in the Charlotte-Mecklenburg County region.

Vehicle Idling Controls was eliminated due to perceived enforcement and monitoring difficulty. Although idling controls would reduce carbon monoxide problems at specific locations, these locations may not coincide with present hot spots. Therefore, this tactic would have marginal impact.

Conversion of fleet vehicles to Alternative Fuels or Engines was eliminated because of its low impact potential. Some alternative fuels, such as diesel, only serve to reduce emissions of a particular pollutant at the expense of

EXHIBIT 2

STATUS OF TCM TYPES IN CHARLOTTE-MECKLENBURG COUNTY REGION

	Strategy	Program Has Been Implemented	Program Scheduled For Implementation	Further Evaluation Required	Implementing Agency
1.	Vapor Recovery Program			o	
2.	Improved Public Transit	o	o		TPO
3.	Exclusive Bus and Carpool Lanes			o	
4.	Areawide Carpool Programs	o			Charlotte-Mecklenburg Ride Share Program
5.	Private Car Restrictions			o	
6.	Long-Range Transit Improvements			o	
7.	On-Street Parking Controls			o	Traffic Engineering Department
8.	Park-n-Ride and Fringe Parking Lots	o			
9.	Pedestrian Malls			o	
10.	Employer Based Ridesharing	o			Charlotte-Mecklenburg Share Program
11.	Bicycle Lanes and Storage Facilities	o		o	
12.	Staggered Work Hours			o	
13.	Road Pricing			o	
14.	Vehicle Idling Controls			o	
15.	Traffic Flow Improvements	o	o		Traffic Engineering Department
16.	Alternative Fuels or Engines			o	
17.	Vehicle Retrofit			o	
18.	Cold Start Emissions Reduction			o	

an increase in the emissions of another pollutant. Fuels which are not abundant, such as propane, would improve vehicle emissions, but may force other users to switch to fuels which may cause more negative impacts. Even if a cleaner burning fuel is used, the number of vehicles which potentially could be converted is a small portion of the total vehicle-mix in the region. Therefore, emission reductions would be limited. These impacts would also be distributed throughout the region, making this tactic not directly applicable at the localized hot spot level. The implementation costs of such a program may be high and require private sector participation.

Programs for Vehicle Retrofit will not be considered further due to their low impact as well as high implementation costs. As was the case with the previous strategy, the size of the vehicle fleet which could be adapted is small. Impacts would again be at the regional level and not the localized level. The implementation costs would present a problem, not just because of the magnitude, but also due to the lack of incentives for private owners to adopt this strategy.

Programs to Reduce Cold Start Emissions are not applicable in the Charlotte-Mecklenburg County region. By definition, the first 505 seconds of all vehicle trips are made in the start mode, which is classified as either cold or hot. The reduction of cold start emissions can only be accomplished by incurring more hot starts, or by reducing the number of vehicle trips. However, the emissions caused by hot starts are of equal concern as those caused by cold starts. Because TCMs specifically aimed at reducing vehicle trips are examined elsewhere, the reduction of cold start emissions will not be considered as a separate category.

As discussed above, six TCM strategies were removed from the original list of eighteen. In addition, some measures were combined into single categories with other strategies. PMM&Co. feels that Areawide Carpool Programs should be considered as a class along with Employer-Based Ridesharing under a single title, Ridesharing, since these two strategies are similar in the scale and method of implementation. Similarly, Private Car Restrictions has been merged into the TCM category of Pedestrian Malls, as these two strategies are similar in implementation, results, and air quality impacts.

BENEFITS OF SELECTED STRATEGIES

The ten remaining TCM strategies are those which PMM&Co. feels are appropriate for addressing CO hot spot problems in the Charlotte-Mecklenburg County region. The impacts of each are discussed here.

One method which simultaneously addresses both regional and localized air quality problems is that of Traffic Flow Improvements. Changes in traffic signalization techniques aimed at improving flow on an arterial or within a

network can have large impacts on vehicle operating speeds, as is shown in Exhibit 3. As a result of signal coordination and computerized signal controls, average speeds on arterials during peak periods have increased by as much as 30 percent. A TRANS simulation produced an estimate that a peak hour speed increase of 25.8 percent was achieved by timing plan optimization of ten interconnected signals in Charlotte. Similar speed increases have also occurred at the network level. Increased vehicle speeds along with less frequent stops and starts lead to reductions in CO emissions. These reductions can be very effective at alleviating CO hot spot problems, as well as contributing to the improvement of regional air quality. However, these are economic costs associated with both implementation and maintenance. The implementation costs of a computer control system range from $5,000 to $13,000 per signal. Operations and maintenance costs can range from hundreds of dollars annually per signal for non-computer signal optimization, to over a thousand dollars annually per signal for computerized control (See Exhibit 3). But each dollar spent produces many hours of vehicle time savings.

Other tactics, such as changing the lane operation of a roadway, can increase speeds and improve air quality by increasing the capacity of a facility. This action has low implementation costs, as only signs and surface restriping are necessary. Each of the measures discussed here are applicable at locations and times where congestion exists or where vehicles experience unnecessary waiting times.

Exclusive Bus and Carpool Lanes are also effective at improving air quality on a regional level, and can be very effective at improving air quality on the particular facility where the lanes are implemented. When implemented on a congested facility by adding an additional lane for high-occupancy vehicles (HOVs), this tactic results in increased speeds for all vehicles. Air quality improvements are realized in turn due to the speed increase as well as due to any induced mode shift to high-occupancy vehicles, an action which reduces regional vehicle-miles of travel (VMT). One drawback to this technique is high implementation costs, which could be millions of dollars for an exclusive guideway facility. Both impacts and costs of HOV facilities are presented in Exhibit 4. An alternative is to reserve an existing lane for HOVs by prohibiting access by other vehicles. This technique must only be used when the remaining lanes have sufficient capacity to accommodate the existing traffic volumes without inducing congestion. Otherwise, the local pollution and traffic congestion problems may worsen. But a properly selected and implemented bus and carpool lane can reduce emissions by increasing vehicle speeds and making high-occupancy travel more attractive. Evidences supporting this are also given in Exhibit 4.

On-Street Parking Controls can be used to improve traffic flow or to induce a mode shift. When curb parking is prohibited, the capacity of a roadway can increase substantially, as is indicated in Exhibit 5. On a congested facility, this leads to reduced CO emissions as a result of increased speeds. Preferential parking for carpools is an incentive for commuters to shift from

EXHIBIT 3:
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Freeway Ramp Control					18
Actual					
Minneapolis, I-35W Inbound		+14% Freeway Speed AM Peak		$101,000/mile equivalent 1980 cost	
		+34% Freeway Speed AM Peak Hr.			
I-35W Outbound		+19% Freeway Speed PM Peak			
Chicago, Eisenhower Expressway Inbound		+9% Speed 2-hr AM Peak			
		+5% Speed 4-hr AM Peak			
Los Angeles, Santa Monica Freeway Inbound		+40% Speed AM Peak Pd.			
Houston, Gulf Freeway Inbound		+60% Speed AM Peak Hr.			
Los Angeles, Harbor Freeway Inbound		+55% Speed PM Peak Pd.			
Detroit, Lodge Freeway Inbound		+33% Speed PM Peak Pd.		$506,000/mile equivalent 1980 cost (86% for buried communication cable)	

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS		COST	SOURCE
		SPEED	VMT		
Improved Signalization Signal Coordination, Optimization, Advanced Master Control					18
Actual					
Columubs, GA CBD		+34% Avg. Speed AM Pk +40% Avg. Speed Off-peak +32% Avg. Speed PM Pk			
NYC 21 Arts., 886 Signals		+32% Avg. Speed AM Pk +16% Avg. Speed Off-Peak +33% Avg. Speed PM Pk.			
Metro Dade 6 Arts, 84 Sig.		+18% Avg. Speed AM Pk +22% Avg. Speed PM Pk.			
Thunder Bay, Ont. CBD		+19% Avg. Speed AM Pk. +20% Avg. Speed Off-peak +8% Avg. Speed PM Pk.			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Signal Coordination					18
Actual					
LA Broadway-Figueroo (26 Int)		+22.7% Avg. Speed PM Peak			
LA Pico Boulevard (6 Int)		+18.0% Avg. Speed Off-Peak			
		+6.4% Avg. Speed PM Peak			
LA Wilshire (45 Int)		+9.9% Avg. Speed AM Peak			
Macon, GA CBD (54 Int)		+3.4% Avg. Speed AM Peak			
		+17.1% Avg. Speed PM Peak			
Inglewood, CA (60 Int)		+35.0% Avg. Speed AM Peak			
		+36.0% Avg. Speed PM Peak			
Montgomery, AL CBD (50 Int)		+24.1% Avg. Speed AM Peak			
		+6.1% Avg. Speed Off-Peak			
		+10.8% Avg. Speed PM Peak			
Charlotte, NC CBD Fringe (10 Int)		+25.8% Avg. Speed PM Peak			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Washington CBD (40 Int)		+10.4% Avg. Speed Off-Peak			18
Fort Worth CBD (132 Int)		+1.9% Avg. Speed AM Peak			
Santa Barbara Arterial (8 Int)		+12.0% Avg. Speed Off-Peak			
		+16.5% Avg. Speed PM Peak			
		+15.1% Avg. Speed AM Peak			
		+3.9% Avg. Speed Noon			
		+7.0% Avg. Speed PM Peak			
Computerized Master Control of Previously Interconnected Signals					18
Actual					
Charleston, SC		+12 Avg. Speed AM Peak			
		+21% Avg. Speed PM Peak			
Raleigh, NC CBD		+6% Avg. Speed AM Peak			
		+12% Avg. Speed Off-Peak			
		+12% Avg. Speed PM Peak			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Greensboro, NC CBD		+16% Avg. Speed AM Peak +14% Avg. Speed Off-Peak +19% Avg. Speed PM Peak			
Computerized Master Control of Previously Isolated Traffic-Actuated Signals					18
Actual					
Greensboro, NC Arterials		+7% Avg. Speed AM Peak +7% Avg. Speed Off-Peak +8% Avg. Speed PM Peak			
Louisville, KY Arterial		+13% Avg. Speed AM Peak +16% Avg. Speed Off-Peak +25% Avg. Speed PM Peak			
Atlanta, GA Arterial		+29% Avg. Speed AM Peak +26% Avg. Speed Off-Peak			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
		+30% Avg. Speed PM Peak			
Improved Signalization for Urban Area of 1 Million Population					18
Estimated					
Optimize Signal Timing @ 500 Previously Coordinated Intersections		-12% Regional travel time -1.3% Regional Fuel Cons.		$300 to $400 annually per signal for Operations and Maintenance	
Interconnect and Optimize Signal Timing @ 250 Previously Uncoordinated Intersections		-25% Regional travel time -1.4 % Regional Fuel Cost		$2,000 to $10,000 per signal for implementation $500 to $1,400 annually per signal for Operations and Maintenance	
Install Advanced Computer Control System @ 500 Previously Coordinated Intersections (Marginal Costs & Impacts)		-8% Regional travel time -0.8% Regional Fuel Cons.		$5,000 to $13,000 per signal for implementation $1,100 to $2,000 annually per signal for Operations and Maintenance	
Change Street from Two-Way to One-Way Operations					19
Estimated					
With Parking on Both Sides					
35' Width		+14.7 % Capacity			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
40' Width		+19.6% Capacity			
45' Width		+25.6% Capacity			
50' Width		+27.6% Capacity			
55' Width		+29.8% Capacity			
60' Width		+32.9% Capacity			
No Parking Allowed					
35' Width		+19.3% Capacity			
40' Width		+19.8% Capacity			
45' Width		+20.2% Capacity			
50' Width		+20.4% Capacity			
55' Width		+20.9% Capacity			
60' Width		+21.7% Capacity			

EXHIBIT 3: (Cont'd)
TRAFFIC FLOW IMPROVEMENTS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Reversible Arterial Lanes					15
Estimated					
San Diego Corridor	-15% Radial Arterial Peak Pd. Co.	+20% Radial Arterial Peak Pd. Avg. Speed (+31% in Peak Direction, -23% in Off-Peak)			
Richmond Corridor	-6% Radial Arterial Peak Pd. Co.	+8% Radial Arterial Peak Pd. Avg. Speed (+31% in Peak Direction, -23% in Off-Peak)			
Nashville Corridor	-6% Radial Arterial Peak Pd. Co.	+13% Radial Arterial Peak Pd. Avg. Speed (+31% in Peak Direction, -23% in Off-Peak)			

EXHIBIT 4:
EXCLUSIVE BUS AND CARPOOL LANES

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
Estimated					
Exclusive Bus Lane on Arterial (Atlanta)	-2.4% Regional Peak Pd. Co. -1.4% Regional Peak Pd. HC -2.1% Regional Peak Pd. NOx		-2.0% Regional Peak Pd. VMT -1.2 to -1.6% Peak traffic volume on facility	Bus Lane $125,000 (1977)	8
Exclusive Freeway Lanes (15 Miles) in Urban Area of 1 Million Population		-.4% Regional travel time	-.1% Regional VMT	$5-8 Million (Annualized)	7
Added Freeway HOV Lane					9
San Diego	-2% Regional Co. Emissions -2% Regional Peak Co. Emissions -16% CBD Peak Co. -13% Facility Peak Co. -1% Regional HC Emissions	+1% Regional Avg. Speed +3% Regional Peak. Pd. Avg. Speed +35% Facility Peak Pd. Avg. Speed			
Richmond	-1% Regional Co. Emissions -1% Regional Peak Co -7% CBD Peak Co. -20% Facility Peak Co.	+1% Regional Avg. Speed +2% Regional Peak Pd. Avg. Speed +55% Facility Peak Pd. Avg. Speed			

EXHIBIT 4: (Cont'd)
EXCLUSIVE BUS AND CARPOOL LANES

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
Nashville	-1% Regional Peak Pd. Co. -6% CBD Peak Pd. Co. -9% Facility Peak Co.	+1% Regional Peak Pd. Avg. Speed. +34% Facility Peak Pd. Avg. Speed			
Actual					
San Bernardino Freeway-Busway Exclusive Median Roadway		+55 to +60% Transit Speed on Facility	+900% Peak Pd. Transit Ridership on facility	$57-60 Million (Implementation)	4
Curb Lane on Arterial Reserved for Buses					.4
Baltimore		-17 to -21% Bus travel time		Nominal	
Washington		-35% Bus travel time		Nominal	
Contra-flow Bus Lane and Withflow Carpool Lane on Arterial (Miami)		+7.7% Auto travel time -33% Carpool travel time		$626,000 Implementation $437,500/year Operating	4
Shirley Highway Exclusive Roadway (11 Miles)		13 min. travel time saving in HOV lane (AM) 20 min. travel time saving in HOV lane (PM)	Transit mode share from 21% (1970) to 31% (1974) on highway	$43 Million Implementation $10,000 to $15,000 Annual Operating	4
Banfield Freeway Withflow HOV Lane (1.7 miles EB, 3.3 miles WB)	+2% CO emissions on facility +2% HC emissions on facility	-28% HOV travel time	+2% traffic volume Auto occupancy increased from 1.22 to 1.26 (AM Peak) +10% person volume	$500,000 Construction (1975)	22

EXHIBIT 5:
ON-STREET PARKING CONTROLS

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
Curb Parking Restrictions					16
Actual					
Washington, 1966 (Arterial)	-25% Arterial Co. -20% Arterial HC +7% Arterial NOx	+23% Arterial Peak Hr. Auto Speed +10% Arterial Peak Hr. Bus Speed			
Estimated					
Prohibition of Curb Parking on Arterial				$6,700/miles (1979)	15
Curb Parking Prohibition on Both Sides of a CBD Street		Capacity Increase: 1-way St. / 2-way St.			19
35' Width		58.3% / 52.2%			
40' Width		47.7% / 47.5%			
45' Width		37.9% / 44.1%			
50' Width		32.4% / 40.3%			
55' Width		27.2% / 37.0%			
60' Width		23.9% / 35.3%			
Preferential Parking for Carpools					
Actual					
Portland ($15/mo. meter parking for carpools with permit)			288 permits issued (2/1/79) 3.3 Average Auto Occupancy	6 month budget (9/77 to 2/78) $7,564.67	
Seattle ($5/mo. parking with permit)			193 certified carpools (12/77) 3.18 Average Auto Occupancy.		

single-occupant autos, thereby reducing regional VMT. However, large-scale impacts are not likely. In both cases there are adverse impacts of inconvenience for those looking for an on-street space.

Park-n-Ride and Fringe Parking Lots can have considerable impacts in reducing work trip VMT. The use of park-n-ride lots, located away from the central business district (CBD), will slightly improve regional air quality by reducing VMT. Park-n-ride is more effective in alleviating localized CO problems on freeways and arterials by reducing traffic volumes. A region-wide set of park-n-ride lots can also be very effective in reducing CBD VMT. Impacts of park-n-ride are summarized in Exhibit 6. Fringe parking lots, located at the edge of a CBD, can reduce congestion and improve air quality in the downtown area. Both types of parking facility could involve significant construction costs for new lots, also indicated in Exhibit 6.

Programs of Staggered Work Hours are aimed at reducing peak travel demand by dispersing the time distribution of work trips. On a regional scale, plans such as flextime may have little impact due to a limited potential market. In addition, total travel is not likely to change significantly, as is indicated in Exhibit 7. However, flextime can have a major impact in reducing congestion on a local scale, such as in the vicinity of a large employer. Another technique, the compressed work week, has the potential for large VMT savings, due to the reduction in necessary work trips. However, these trips are often replaced by other trips. Estimates of the implementation impacts of a compressed work week strategy are also presented in Exhibit 7.

Another way of reducing work trip volumes is through the promotion of Ridesharing as shown in Exhibit 8, area-wide ridesharing programs have small region-level impacts. But these impacts can be significant. It is estimated in the North Carolina State Implementation Plan that the Charlotte-Mecklenburg Ride Share Program can save 50,000 VMT per day by 1982, resulting in a 2.3 percent reduction in regional CO emissions. CBD traffic reductions could be significant as well. Employer-based ridesharing, the impacts of which are also presented in Exhibit 8, can improve traffic flow and air quality near large employers, especially during peak travel periods. However, there are significant costs associated with managing ridesharing programs, which generally increase with the number of participants. Ridesharing is also hampered by the need for participants to maintain a fixed commuting schedule, a problem which exists when workplaces are different. This problem can be alleviated somewhat though by implementing a program of flexible work hours along with ridesharing encouragement by employers.

Auto VMT can be reduced by a mode shift resulting form Improved Public Transit. Changes such as increased bus ridership, eliminating auto trips by those who change modes. In Charlotte, the five express bus services presently operating saved an estimated 3,312 miles of travel daily in 1978. This translates to a reduction of 35.2 tons of CO emissions annually. Other impacts of improved transit service are summarized in Exhibit 9. However, when bus service increases,

DENSITY A:
PARK-N-RIDE AND PRIVATE PARKING LOTS

TRANSPORTATION CONTROL MEASURES	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Enforcement					
6 Park-n-Ride Lots (Sprawtown)			-.6% Regional VMT		3
Park-n-Ride Development					10
San Diego	-2% CBD CO Reductions -1% CBD Peak Hr. Co.		-1% CBD Peak Hr. VMT -1% Corridor Peak Hr. VMT		
Richmond	-1% CBD Co Reductions -4% CBD Peak Hr. Co. -1% Corridor Peak Hr. Co.		-2% CBD Peak Hr. VMT -2% Corridor Peak Hr. VMT		
Westwood	-1% CBD Co. Reductions -4% CBD Peak Hr. Co. -1% Corridor Peak Hr. Co.		-1% CBD Peak Hr. VMT -1% Corridor Peak Hr. VMT		
Actual					
3 Private Lots (California)	-22,870 lbs. Co. Annually -5,411 lbs. HC Annually -4,3000 lbs. NOx Annually		-601,250 VMT Annually	$495,000 Construction $3,000 Annual Operations and Maintenance	15
6 Park-n-Ride Lots (Baltimore)			Daily Usage over 1,000 (1977) -8,730 daily VMT		20

EXHIBIT 6: (Cont'd)
PARK-N-RIDE AND FRINGE PARKING LOTS

TRANSPORTATION CONTROL MEASURES	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Continued					
6000's Park and Ride (Boston) 11,000 Spaces at Rail Rapid Transit			82% Avg. Utilization (1979)		20
5,150 Spaces at Commuter Rail			63% Avg. Utilization (1979)		
1,000 Spaces at Express Bus			69% Avg. Utilization (1979)		
73 Park and Ride Lots (Portland)			Daily Usage 1,742		20
6 Park and Ride Lots (Milwaukee)			Daily Usage 400 (1970)		21
6 Park and Ride Lots (Lindenwold)			Daily Usage 6,600 (1971) -28.7 Million Annual VWT		21

EXHIBIT 7:
STAGGERED WORK HOURS

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible]					
[illegible]					
[illegible]			-0.0% Annual regional VMT +.1% Work trip VMT -0.0% Annual regional VMT -0.0% Annual regional VMT -0.0% Annual Work trip VMT -0.0% Annual Work regional fuel cons.		
[illegible]			-0.0% Annual regional VMT -0.0% Work trip VMT VMT -0.0% Annual regional fuel cons. -0.0% Annual regional VMT -0.0% Worktrip VMT -0.0% Annual regional fuel cons.		
[illegible]			-0.0% Annual regional VMT -0.0% Work trip VMT VMT -0.0% Annual regional fuel cons. -0.0% Annual regional VMT -0.0% Work trip VMT -0.0% Annual regional fuel cons.		

EXHIBIT 7:
STAGGERED WORK HOURS (Con't)

TRANSPORTATION CONTROL MEASURES	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
Flexible Work Hours					
Baltimore	-2.0% Regional Peak Pd. VMT		-3.7% Regional Peak Pd. VMT		5
Washington			-4.0% Regional Peak Pd. VMT		6
Work Rescheduling in an Area of 1 Million Population		-4% Regional travel time		$200,000 Annual Operations and Maintenance	7
Compressed Work Week					
4/9 Implementation					
SMSAs w/ low bus transit usage and pop. ≥ 1,000,000			- .4% Annual regional VMT -1.9% Work trip VMT - .5% Annual regional fuel cons.		
SMSAs w/ low bus transit usage and pop. < 1,000,000			- .2% Annual regional VMT -1.7% Work trip VMT - .2% Annual regional fuel cons.		
3/12 Implementation					
SMSAs w/ low bus transit usage and pop. ≥ 1,000,000			- .8% Annual regional VMT -3.6% Work trip VMT - .9% Annual regional fuel cons.		
SMSAs w/ low bus transit usage and pop. < 1,000,000			- .5% Annual regional VMT -3.8% Work trip VMT - .6% Annual regional fuel cons.		

EXHIBIT 7:
STAGGERED WORK HOURS (Con't)

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible] Implementation					
[illegible] w/ low bus transit usage and pop. ≥ 1,000,000			-1.3% Annual regional VMT -5.7% Work trip VMT -1.4% Annual regional fuel cons.		
[illegible] w/ low bus transit usage and pop. < 1,000,000			- .7% Annual regional VMT -5.0% Work trip VMT - .7% Annual regional fuel cons.		

EXHIBIT 8:
RIDESHARING

TRANSPORTATION CONTROL MEASURES	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Actual					
Ridesharing					7
Urban Area	Number of Permanent Ride Carpoolers	Percent Reduction in Total VMT	Percent Reduction In Work Trip VMT	Annual Project Cost	
Los Angeles	8,100	0.07	0.2	$500,000	
Sacramento	2,700	0.25	0.7	287,000	
San Diego	2,300	0.11	0.3	140,000	
Boise	120	0.05	0.14	44,000	
Jacksonville	3,000	0.07	0.2	70,000	
Reno	1,200	0.09	0.26	125,000	
Tulsa	280	0.05	0.14	35,000	
Portland	9,700	0.36	1.0	250,000	
Raleigh	750	0.10	0.3	20,000	
Dallas	1,400	0.04	0.11	62,000	
Fort Worth	1,100	0.10	0.3	31,000	
Houston	1,100	0.08	0.23	120,000	
San Antonio	1,000	0.28	0.8	160,000	
Seattle	3,200	0.07	0.2	215,000	
Washington, D.C.	10,800	0.13	0.37	140,000	
Company - Sponsored Vanpool Programs					25
3M Company		80 Vans		$ 26,100 Implementation $ 18,300 Annual Program Costs	
Trans. Valley Authority		480 Vans		$ 10,600 Implementation $156,300 Annual Program Costs	
Aberjona		78 Vans		$ 16,100 Implementation $ 20,000 Annual Program Costs	
Gannon		37 Vans		$ 40,700 Implementation $ 11,200 Annual Program Costs	
Sancrib		9 Vans		$ 16,500 Implementation $ 4,000 Annual Program Costs	

EXHIBIT 9:
Improved Public Transit

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible]					
[illegible]			-.02% Regional VMT		3
[illegible]			-.22% Regional VMT		3
[illegible]			- .7% Regional Peak Pd VMT		6
[illegible]			- .1% Regional VMT		1
[illegible]			- .3% Regional VMT		1
[illegible]			-1.1 to 2.2% Regional VMT		2/
[illegible]					7.26
[illegible]					
[illegible]				Operating Cost per Bus-Mile	
[illegible]			-.06% Regional VMT +8.3% Transit Ridership		
[illegible]			-.24% Regional VMT +10.9% Transit Ridership	$1.49 (FY 76)	
[illegible]			-.13% Regional VMT +36.4% Transit Ridership	$1.42 (FY 76)	

EXHIBIT 9:
Improved Public Transit (Con't)

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
				Operating Cost per Bus-Mile	
+[illegible] Bus-Miles (San Diego)			-.08% Regional VMT -13.3% Transit Ridership	$1.59 (FY 76) $2.08 (FY 79)	
+[illegible] Bus-Miles (Madison)			-.13% Regional VMT +8.9% Transit Ridership		
+[illegible] Bus-Miles (Eugene)			-22% Regional VMT +271.3% Transit Riderhsip	$ .99 (FY 76)	
+[illegible] Bus-Miles (Raleigh)			+.02% Regional VMT +10.9% Transit Ridership		
+[illegible] Bus-Miles (Bakersfield)			+.06% Regional VMT -49.0% Transit Ridership		
Off-Peak Transit Fare Elimination					
Denver			+35% Transit Ridership +88% Off-Peak Ridership -19% Peak Pd. Ridership 10% of Off-Peak trips induced	$3.7 Million lost Revenue/yr	
Evanston			+12% Transit Ridership +46% Off Peak Ridership -5% Peak Pd. Ridership 14% of Off-Peak Trips induced	$338,000 lost revenue/yr	

bus VMT increases as well; therefore there may be an emissions trade off. In the cases of both a service increase and reduced fares, bus operating deficits increase, making this strategy less appealing than those strategies already discussed. In addition, some of the auto work trips eliminated may be offset by non-work trips which can be made by other hourshold members using the auto left at home.

One method of eliminating localized CO problems caused by automobiles is to create Predestrian Malls. However, this method usually just results in diffusing the problem to other locations. Local travel may actually increase due to the resulting traffic diversions, as indicated by the estimates given in Exhibit 10. Therefore the net air quality impact may actually be negative. Implementation costs may also be high, especially if the mall is to accommodate transit service. However, there are positive impacts resulting from malls, such as increased sales volume, a more attractive downtown area, and possibly improved transit service in the case of a transit mall. To be successful, a pedestrian mall requires the support of the local business community.

Bicycle Lanes and Storage Facilities have little impact on regional air quality. Most commuters do not perceive bicycling as a viable means of transportation to work. Time, distance, and weather considerations are major factors in that assessment. However, special facilities would improve the quality of bicycle trips and possibly induce additional cycling interest. The costs of various types of bicycle facilities are listed in Exhibit 11.

Regional air quality improvements can result from reduced auto VMT brought on by Road Pricing policies. Policies aimed at reducing work trips by auto can also result in local and CBD air quality improvements. The estimated impacts of many such policies are summarized in Exhibit 12. Increases in gasoline prices appear to be the most effective in reducing regional VMT; parking cost increases also have significant impacts. However, the technique of imposing auto travel disincentives as opposed to incentives to use other modes is certain to be unpopular, and implementation may be very difficult. Also, local agencies may in some cases not have the legal authority or ability to implement pricing policies. But if auto disincentives are imposed, it is imperative that comparable transportation alternatives be available. This technique should be used only when necessary and decisions regarding the location of pricing disincentives must be made cautiously.

RANKING OF SELECTED STRATEGIES

The previous section discussed the impacts of the ten TCM strategies which [redacted]Co. feels are appropriate for addressing CO hot spot problems in the Charlotte-Mecklenburg County region. Those which were found to be the most appropriate are Traffic Flow Improvements, Exclusive Bus and Carpool Lanes, and On-Street Parking Controls. Each of these strategies is very effective at increasing traffic speeds on congested facilities, locations where CO hot spots

EXHIBIT 10:
PEDESTRIAN MALLS

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible]					
[illegible]					
[illegible]			+.08% Regional VMT		7
[illegible]			+.1% Regional VMT		7
[illegible]			-.4% Regional VMT		1
[illegible]	+1% CBD CO Emissions +1% CBD Peak Pd. CO		+3% CBD VMT +3% CDB Peak Pd.VMT		11
[illegible]	+1% CBD CO Emissions +1% CBD Peak Pd. CO		+2% CBD VMT +2% CDB Peak Pd.VMT		11
[illegible]	+1% CBD CO Emissions +1% CBD Peak Pd. CO		+3% CBD VMT +3% CDB Peak Pd.VMT		11
[illegible]					
[illegible]			+.01% Regional VMT		7
[illegible]					23
[illegible]					
[illegible]				$15 Million Const. (1978)	
[illegible]				$7 Million Const. (1976)	
[illegible]				$3.8 Million (Const. (1967)	

EXHIBIT 11:
BICYCLE LANES AND STORAGE FACILITIES

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible]	Trace decrease in regional CO, HC, and NO_x emissions.		Trace decrease in regional VMT.	Class I (exclusive facility): $8,000 to $70,000 per mile Class II (reserved lane): $1,900 to $6,000 per mile Class III (signs): $500 to $1,500 per mile	12
[illegible]				Racks: $25 to $100 per bike ($66 to $160 coin-op) Lockers: $160 to $250 per bike.	

EXHIBIT 12:
ROAD PRICING

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Estimated					
Increase Gasoline Price by 20¢ per Gallon (Baltimore)			-1.5 Regional Peak Pd. VMT		5
Double Gasoline Price (Washington)			-5.1 Regional VMT		1
Triple Gasoline Price (Washington)			-9.7 Regional VMT		1
Quadruple Gasoline Price (Washington)			-13.8% Regional VMT		1
Increase Gasoline Price to $2.25 per Gallon (Urban Area)	-8% to -17% Regional CO	+3% to +7% Regional Avg. Speed.	-7% to 16% Regional VMT		13
	-7% to -16% Regional HC	+23% to +51% Regional Peak Pd. Speed	-19% to -34% Regional Peak VMT		
	-6% to -12% Regional NO_x				
	-27% to -45% Regional Peak Pd. CO	+4% to +7% CBD Avg. Speed	-10% to -17% CBD VMT		
	-13% to -19% CBD CO Emissions	+15% to +32% CBD Peak Pd. Speed	-12% to -24% CBD Peak Pd. VMT		
	-21% to -32% CBD Peak Pd. CO	+20% to +44% Radial Freeway PeakPd. Avg. Speed	-18% to -31% Radial Freeway Peak Pd. VMT		
	-20% to -48% Radial Freeway Peak Pd. CO	+22% to +50% Radial Arterial Peak Pd. Speed	-19% to -34% Radial Arterial Peak Pd. VMT		
	-29% to -55% Radial Arterial Peak Pd. CO				

EXHIBIT 12: (Cont'd)
ROAD PRICING

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
Unlimited					
Vehicle Ownership Tax (Washington)					
$100/Vehicle			-.1% Regional VMT		1
$200/Vehicle			-.2% Regional VMT		
$400/Vehicle			-.4% Regional VM		
$1 Parking Surcharge (Baltimore)	-.3% Regional 8-hr. CO -.3% Regional Peak Pd. HC		-8% Regional Peak Pd. VMT		5
$2 parking Surcharge (Baltimore)	-.7% Regional 8-hr. CO -.8% Regional Peak Pd. HC		-1.5% Regional Peak Pd. VMT		5
Downtown Parking Cost Increase (Washington)					
$1			-.8% Regional VMT		1
$2			-1.7% Regional VMT		
$3			-2.5% Regional VMT		
CBD Parking Cost Increase (Washington)					
$1			-.3% Regional VMT		1
$2			-.6% Regional VMT		
$3			-.9% Regional VMT		

EXHIBIT 12: (Cont'd)
ROAD PRICING

[illegible]	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	VMT	COST	SOURCE
[illegible]					
[illegible]	-6% to -8% Regional CO	+2% to + 3% Regional Avg. Speed	-5% to -6% Regional VMT		13
	-4% to -7% Regional HC	+11% to +20% Regional Peak Pd. Speed	-10% to -17% Regional Peak Pd. VMT		
	-2% to -6% Regional NO_x	+2% to +4% CBD Avg. Speed	-0% to -8% CBD VMT		
	-15% to -25% Regional Peak Pd. CO	+0% to +17% CBD Peak Pd. Speed	-0% to -14% CBD Peak Pd. VMT		
	-4% to -10% CBD Peak	+11% to +17% Radial Freeway Peak Pd. Avg. Speed	-10% to -14% Radial Freeway Peak Pd. VMT		
	-6% to -15% CBD Peak Pd. CO	+10% to +19% Radial Arterial Peak Pd. Avg. Speed	-0% to -16% Radial Arterial Peak Pd. VMT		
	-10% to -20% Radial Freeway Peak Pd. CO				
	-19% to -29% Radial Arterial Peak Pd. CO				
[illegible]					
$4.00			-5.04% Regional VMT		14
$6.00			-9.58% Regional VMT		
$8.00			-13.07% Regional VMT		
$10.00			-15.43% Regional VMT		

EXHIBIT 12: (CONT'D)
ROAD PRICING

TRANSPORTATION CONTROL MEASURE	AIR QUALITY IMPACTS	TRAVEL IMPACTS SPEED	TRAVEL IMPACTS VMT	COST	SOURCE
Actual					
Parking Rates for Federal Employees raised from 0% to 70% of Commercial Rate (Ottawa)			-23% Federal Employees Driving to Work Auto Occupancy from 1.33 to 1.41 +16% Federal Employees Commuting by Bus		
15% Tax on Off-Street Parking (San Francisco)			-31% Parking Revenues		

are most likely to be. The other strategies are also effective at increasing vehicle speeds or reducing VMT, but their impacts are spread out geographically and would have less impact on specific hot spot locations. These measures supplement the three major ones listed above. The ten TCMs which PMM&Co. feels are appropriate for addressing CO hot spot problems are listed in order in Exhibit 13, beginning with the most appropriate and continuing to the least appropriate. This ranking is based on the information presented in the previous exhibits, as well as PMM&Co.'s knowledge regarding implementation procedures and problems. Each strategy is recommended for potential implementation after due consideration of specific hot spot conditions. However, emphasis should be placed on those at the top of the list.

EXHIBIT 13

TCM SELECTION AND ORDERING

1. Traffic Flow Improvements
2. Exclusive Bus and Carpool Lanes
3. On-Street Parking Controls
4. Park-n-Ride and Fringe Parking Lots
5. Staggered Work Hours
6. Ridesharing
7. Improved Public Transit
8. Pedestrian Malls
9. Bicycle Lanes and Storage Facilities
10. Road Pricing

REFERENCES

1. Cambridge Systematics, Inc. Carpooling Incentives: Analysis of Transportation and Energy Impacts. Prepared for the Federal Energy Administration, June 1976.

2. John F. DiRenzo et. al. An Assessment of Immediate Action Travel Reduction Strategies for Achieving Air Quality and Energy Conservation Objectives. Paper presented at the 1975 Intersociety Conference on Transportation, Atlanta, Georgia, July 1975.

3. New York State Department of Transportation. Impacts of Transportation Policies on HC and CO: Procedures for Meeting the Planning Requirements of the Clean Air Act as Amended, August 1977. Albany, New York, May 18, 1978.

4. Peat, Marwick, Mitchell & Co. Air Quality Impacts of Transit Improvements, Preferential Lane, and Carpool/Vanpool Programs. Prepared for Environmental Protection Agency, March 1978.

5. R. H. Pratt Associates, Inc. Evaluation of Candidate Transportation Control Strategies for the Baltimore Region. Technical Memorandum No. 3 prepared for Maryland Department of Transportation, December 1976.

6. R. H. Pratt Associates, Inc. Transportation Controls for Air Quality Improvements in the National Capital Region. Prepared for Study Management Working Group National Capital Region, Transportation/Air Quality Study, October 1976.

7. Fred A. Wagner and Keith Gilbert. TSM: An Assessment of Impacts. Prepared for Urban Mass Transportation Administration and Federal Highway Administration, November 1978.

8. Charles M. Abrams and John F. DiRenzo. Measures of Effectiveness for Multimodal Urban Traffic Management. Prepared for Federal Highway Administration, December 1979.

9. Frederick A. Wagner. Transportation Impacts of Pribrity Treatments of High-Occupancy Vehicles. Working Paper No. 13 prepared for Urban Mass Transportation Administration and Environmental Protection Agency, April 1979.

10. William A. Simpson. Park-and-Ride/Express Bus Impact Analysis. Working Paper No. 2 prepared for Urban Mass Transportation Administration and Federal Highway Administration, revised March 1979.

11. William S. Herald. Transportation Impacts of Auto Restricted Zones. Working Paper No. 4 prepared for Urban Mass Transportation Administration and Federal Highway Administration, revised April 1979.

12. Keith Gilbert. Improvement of Pedestrian & Bicycle Facilities. Working Paper No. 10 prepared for Urban Mass Transportation Administration and Environmental Protection Agency, January 1979.

13. Keith Gilbert. Transportation Pricing. Working Paper No. 8 prepared for Urban Mass Transportation Administration and Environmental Protection Agency, June 1979.

14. Barbara Keyani and Evelyn Putnam. Transportation System Management: State of the Art. Prepared for Urban Mass Transportation Administration and Federal Highway Administration, February 1977.

15. Scott Seeburger. Traffic Engineering Improvements. Working Paper No. 11 prepared for Urban Mass Transportation Administration and Environmental Protection Agency, April 1979.

16. Transportation and Communication Department. How to Get the Most Out of Our Streets. Washington, D.C.: Chamber of Commerce of the United States.

17. D. J. Hanson. "Parking Restrictions and the Curb Lane," Special Report 93, Washington, D.C.: Highway Research Broad, 1967.

18. Frederick A. Wagner. Overview of the Impacts and Costs of Traffic Control System Improvements. Prepared for Federal Highway Administration, March 1980.

19. Louis J. Pignataro. Traffic Engineering: Theory and Practice. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1973.

20. John F. DiRenzo, Bart Cima, and Edward Barber. Study of Parking Management Tactics. Prepared for Federal Highway Administration, December 1979.

21. Raymond Ellis, John Bennett, and Paul Rassam. Fringe Parking and Intermodal Passenger Transportation: Operational Experience in Five Cities. Prepared for Federal Highway Administration, November 1971.

22. Oregon Department of Transportation Metropolitan Branch. Branfield High Occupancy Vehicle Lanes Final Report. Prepared for Federal Highway Administration, March 1978.

23. Richard Edminster and David Koffman. Streets for Pedestrians and Transit: An Evaluation of Three Transit Malls in the United States. Prepared for Urban Mass Transportation Administration, February 1979.

24. Bruce D. Spear, et. al. Service and Methods Demonstration Program Annual Report. U.S. Department of Transportation, August 1979.

25. Chris Johnson, Ashish K. Sen, and Claire McKnight. "Carpool and Vanpool Subsidies: The Hidden Cost of Ridesharing." Proceedings of 19th Transportation Research Forum, Volume XIX, No. 1, 1978.

26. American Public Transit Association. Transit Operating Report for calendar/fiscal year 1976. c 1978.